

# Midwest Vegetable Production Guide for Commercial Growers

# 2020

## Illinois

University of Illinois Extension  
C1373-20

## Indiana

Purdue Extension  
ID-56

## Iowa

Iowa State University Extension and Outreach  
FG 0600

## Kansas

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MF3279

## Michigan

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## Minnesota

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BU-07094-S

## Missouri

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MX384  
Lincoln University of Missouri  
Cooperative Extension and Research  
LUCER 01-2020

## Ohio

Ohio State University Extension  
Bulletin 948



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For the most up-to-date version of this publication, visit:

**[mwveguide.org](http://mwveguide.org)**

Changes will be made throughout the year as they are received.

## Abbreviations Used in This Guide

<b>PHI</b>	pre-harvest interval — the minimum allowable time in days between the latest pesticide application and crop harvest
<b>AI</b>	active ingredient
<b>COC</b>	crop oil concentrate
<b>D</b>	dust formulation
<b>DF, DG</b>	dry flowable or water dispersible granule formulation
<b>E, EC</b>	emulsifiable concentrate
<b>F</b>	flowable formulation
<b>G</b>	granular formulation
<b>L, LC</b>	liquid concentrate formulation
<b>NIS</b>	nonionic surfactant
<b>REI</b>	re-entry interval
<b>RUP</b>	restricted use pesticide
<b>SC</b>	suspension concentrate
<b>W, WP</b>	wettable powder formulation

**Cover photo:** Lettuce is just one of the crops that can be managed using the updated **Midwest Vegetable Production Guide for Commercial Vegetable Growers 2020**. The online guide is now searchable and accessible on any platform, including desktop computer, laptop, tablet or data phone. Go to [mwveguide.org](http://mwveguide.org) and search for crop, pest or control. For example, choose *leaf lettuce* under Crop and *drop of lettuce* under Pest to obtain a listing of pest information, several conventional fungicides and a biopesticide that may qualify for organic production.

Insect, disease, and weed control recommendations in this publication are valid only for 2020. If registration for any of the chemicals suggested is changed during the year since the time of publication (December 2019), we will inform all area and county Extension staff. If in doubt about the use of any chemical, check with your Extension agent or chemical company representative.

The information presented in this publication is believed to be accurate but is in no way guaranteed. The authors, reviewers, publishers, and their institutions assume no liability in connection with any use for the products discussed and make no warranty (expressed or implied) in that respect. Nor can it be assumed that all safety measures are indicated herein or that additional measures may be required. The user, therefore, must assume full responsibility, both as to persons and as to property, for the use of these materials including any that might be covered by patent. Always refer to the pesticide labels before each application. If the label information is different than the information presented in this guide, always follow the product label.

# Midwest Vegetable Production Guide for Commercial Growers 2020

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# Statement of Purpose

The management practices, products, and cultivars discussed in this publication are the research- and experience-based recommendations of the institutions associated with the contributing editors and authors. These recommendations are not exhaustive and other practices and products not mentioned in this guide might also be effective. *Read and follow label instructions before using any pesticide product.*

## Acknowledgements

The searchable, digitized update to the Midwest Vegetable Production Guide introduced for 2020 could not have been accomplished without the financial support of the following organizations.

- A grant from the North-Central IPM Center provided to the Great Lakes Vegetable Working Group
- A grant from the MSU Extension Agriculture and Agribusiness Institute Project GREEEN Research Fund
- A gift from the Michigan Vegetable Council
- A gift from the Indiana Vegetable Growers Association
- A gift from the Kansas Vegetable Growers



## What's New in 2020?

### New and Revised Sections

- The online guide at [mwveguide.org](http://mwveguide.org) has been updated to be searchable and accessible on computers, tablets or data phones. Online users of the guide are asked to choose a crop, pest or control to begin a search.
- Information for each product in the online guide has been expanded to include greenhouse use, bee precautions, mode-of-action information and much more.
- The printed version of the guide has a new look as well. Users will note that common names of pesticides are now included with each product as well as restricted entry intervals (REI) and pre-harvest intervals (PHI).
- The Organic Vegetable Production section has updated contacts for certifiers.

### Disease Management

- All fruiting vegetable crops — eggplant, pepper and tomato — have been combined in the same disease section (pages 143-152 in the printed version).

Likewise, all cucurbit crops have been combined in the same disease section (pages 122-132).

- In the printed version of the guide, scientific names are now included with disease names at the beginning of a section. For example, see *bacterial spot of tomato/peppers-Xanthomonas bacteria* on page 146.
- Because scientific names are now included in the disease names, some of the names appear differently. For example, Septoria leaf blight of tomato is now *leaf blight of tomatoes-Septoria fungus*.

### Weed Management

- Zidua® has been added as a preemergence herbicide for potatoes under an updated 24c label.
- Dual Magnum® has expanded uses in some states under updated 24c label.
- Certified applicators must successfully complete an EPA-approved training program before mixing, loading and/or applying paraquat. The training provides important information about paraquat's toxicity, new label requirements and restrictions, and the consequences of misuse. For more information and a link to the training visit: <https://www.epa.gov/pesticide-worker-safety/paraquat-dichloride-training-certified-applicators>

### Insect Management

- Harvanta® has been added to the Cole Crops, Vine Crops, Fruiting Vegetables, and Okra sections for caterpillar, aphid, beetle, and stink bug management.
- The Torac 15E® label has been expanded for thrips to include Cole Crops, Onions and Tomatoes.
- PQZ® and Versys Inscal 0.83DC® are both labeled for aphids on leafy green crops.
- In some chapters, entries have been condensed into generic headings — “Caterpillars,” “Stink Bugs,” “Leafhoppers” and “Mites.” Some products are not for use on all caterpillars, stink bugs, leafhoppers or mites. While application notes call attention to these details, be sure to check the label for specifics.
- We have included Lorsban® (active ingredient, chlorpyrifos) in the Asparagus, Cole Crops, Leafy Greens, Legume, Mint and Sweet Corn sections of this guide. However, at this writing, the U.S. EPA is in discussions with stakeholder groups concerning possibly revoking tolerances for this product. Check with an extension specialist or company contact.

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The University of Illinois publishes Illinois Fruit and Vegetable News, a newsletter that covers production practices and insect, disease, and weed management. It is available at [ipm.illinois.edu/ifvn](http://ipm.illinois.edu/ifvn). For information or to order, contact Nathan Johanning, Local Food Systems and Small Farms Extension Educator at 618-687-1727 or [njohann@illinois.edu](mailto:njohann@illinois.edu). Fact Sheets about vegetable and fruit crops from the University of Illinois are available at [extension.cropsci.illinois.edu/fruitveg](http://extension.cropsci.illinois.edu/fruitveg).

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### ***Purdue Extension Vegetable Crops Hotline***

Purdue Extension issues a biweekly vegetable newsletter to growers throughout the vegetable growing season at a nominal cost. This newsletter provides timely information on disease, weed, and insect activity and management, as well as cultural and postharvest information. To subscribe, send your name, address, and phone number, along with a check for \$15, payable to Purdue University to:

Vegetable Crops Hotline  
Southwest Purdue Ag Program  
4369 N. Purdue Road  
Vincennes, IN 47591

Subscribers to the hotline also will receive emailed updates at no extra cost. Please indicate email address. The hotline also is available free at [vegcropshotline.org](http://vegcropshotline.org).

**Iowa**Iowa State University Extension: [www.extension.iastate.edu](http://www.extension.iastate.edu)

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The state of Missouri has two land-grant institutions: University of Missouri and Lincoln University of Missouri. This table includes contact information of Extension agents from both universities.

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Southwest	Greene, Christian, Taney, Webster, Wright, Ozark, Douglas, Texas and Howell	Patrick Byers, Regional Horticulture Specialist University of Missouri 417-859-2044; byerspl@missouri.edu	Vegetable Production
	Jasper, Barry, Barton, Jasper, Dade, Lawrence, McDonald, Newton, and Stone	Robert Balek, Regional Horticulture Specialist University of Missouri 417-358-2158; balekr@missouri.edu	Vegetable Production
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*continued next page*

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The Ohio State University publishes the VegNet newsletter nearly weekly during the season and less frequently off-season. The newsletter covers production practices and insect, disease, and weed management. It is available free at [vegnet.osu.edu](http://vegnet.osu.edu). For information or to order, contact Sally Miller, Department of Plant Pathology, Ohio State University; 330-263-3678; or [miller.769@osu.edu](mailto:miller.769@osu.edu).

# Soil Fertility and Nutrient Management

Soil tests aid vegetable growers with their soil fertility and fertilizer application programs. Soil tests are most useful when growers keep accurate records for each field that include the amount of fertilizers and other soil amendments they applied, crop yields, and rotations. These records allow growers to determine trends in soil fertility and crop response to applied fertilizers over several years.

Efficient vegetable production relies on growers adjusting lime and fertilizer applications to their soils' existing pH and fertility levels. Growers can increase their net returns if they maintain proper soil fertility, which can reduce crop losses from physiological disorders. Applying nutrients based on crop needs and existing soil nutrient levels also reduces the movement of nutrients into groundwater and surface waters.

Take soil samples at the same time each year, preferably in the fall or early spring. Soil pH varies seasonally, so comparing winter and summer samples is difficult. A typical soil test for plants usually determines pH, lime index (also called buffer pH), available Bray P1 phosphorus (P), exchangeable potassium (K), calcium (Ca), magnesium (Mg), and cation exchange capacity. It also includes the percent base saturation of Ca, Mg, and K.

In addition to the routine pH test, growers should test soils that are susceptible to large variations in soil pH for salt pH. The salt pH provides a more accurate estimate of the true acidity in these soil types by simulating the effects of fertilizer salts on soil pH.

There are also tests to determine organic matter and other nutrients, including sulfur (S), manganese (Mn), boron (B), and zinc (Zn). Some labs test for microbial activity and water-soluble carbon, which can predict the release of nitrogen and phosphorus from organic sources.

Your land-grant university or extension service can provide you with a list of soil testing labs in your area.

## Soilless Growing Media

Test soilless growing media used in transplant or crop production for pH and total soluble salts before using it. Request a test specifically for "soilless media" from the lab. If the crop will be grown in soilless media more than a month, regularly test the media or plant tissue to catch any nutrient imbalances that may affect crop growth and yield.

## Interpretation of Standard Soil Test Results

- **Soil pH** (sometimes called active soil acidity) is based on the pH scale, which measures the acidic or basic reaction of the soil. A pH less than 7 is acidic; a pH greater than 7 is alkaline. When soil pH is too low for good crop growth, adding lime will raise the pH. Natural processes and agricultural practices tend to lower pH over time, so it is important to measure it every year or two. When soils are alkaline, the testing laboratory may recommend applying sulfur (S) to lower the pH to a level that allows nutrient availability in the soil.
- **Lime index** (sometimes called "buffer pH") measures reserve soil acidity. The lime index is used to make limestone recommendations. It usually takes lime four to six months to correct soil acidity. Your land-grant university or extension service can provide you with liming recommendations specific to your state.
- **Phosphorus** may be reported as P (phosphorus) or  $P_2O_5$  (phosphate). The units for P and other nutrient values may be given as parts per million (ppm) or pounds per acre. The value is an estimate of the amount of phosphorus in the soil that the plant can use for growth. Applying  $P_2O_5$  fertilizer at 100 pounds per acre will increase the soil P test level by about 10 pounds per acre.
- **Potassium** may be reported as K (potassium) or  $K_2O$  (potash). The test value estimates the amount of K available per acre. About 50 percent of the potassium applied in fertilizers is fixed in the soil and is not immediately available to plants — this can vary by soil type and clay content. Soil K declines due to crop removal, leaching, and soil erosion.
- **Calcium (Ca) and magnesium (Mg)** soil test values represent the amount of Ca and Mg available in the soil. Ca and Mg values generally are low when soils are acidic. Levels are usually sufficient when pH and the lime test index are at proper levels.

• **Cation exchange capacity (CEC)** is a measure of the soil's ability to hold exchangeable cations such as hydrogen (H), Ca, Mg, K, sodium (Na), iron (Fe), and aluminum (Al). CEC is measured in terms of milliequivalents (meq) per 100 grams of soil. Soil type and soil organic matter determine CEC. Clay-, silt- and loam-type soils generally have a higher CEC than sandy soils because they have many more exchange sites to hold cations. High-CEC soils generally hold nutrients better than low-CEC soils. High-CEC also lose smaller amounts of nutrients due to leaching.

Here are the typical CEC ranges of various soil types:

Soil Texture	CEC Range
Sands	5-15
Silts	8-30
Clays	25-50
Organic soils	50+

• **Base saturation** is the percentage of the total CEC occupied by basic cations such as Ca, Mg, and K. Base saturation is related to soil pH and soil fertility. On acid soils, the percent base saturation of Ca and Mg is low. The saturation of the different cations is important because plants take up some cations more easily than others. The base saturation for Ca should be 60 percent or more; Mg should range between 10 and 15 percent; K should range from 1 to 5 percent. Excess levels of one cation can reduce the uptake of another. Some soil scientists believe that there should be specific Ca:Mg ratios and Mg:K ratios (2:1). Most horticulturists believe that if base saturation levels are at the minimum levels suggested here, then it is not important to maintain specific proportions or ratios.

## Crop Nutrient Requirements

Vegetable crops require 17 essential elements (nutrients) for development and reproduction. In addition to carbon (C), hydrogen (H), and oxygen (O), plants need macronutrients in large concentrations and micronutrients in relatively small concentrations.

Each crop has a crop nutrient requirement (CNR) for particular nutrients. The CNR is defined as the total amount of the nutrient (in pounds per acre) the crop requires to produce optimum economic yield. The concept of optimum economic yield is important in vegetable production, because applying a certain amount of a nutrient might produce a lot of biomass, but may produce negligible marketable product due to small fruit

size, small number of fruits, or large number of culs and small number of marketable fruits. Always consider fruit number, size, and quality in the CNR concept for vegetable production.

The best way to achieve the CNR is to begin with a soil test. The results from a soil lab analysis include recommendations for the amount of lime or sulfur needed to balance the soil pH, and indicate the amount of fertilizer needed to deliver the CNR.

## Macronutrients

Nitrogen (N), phosphorus (P), and potassium (K) are the primary macronutrients, and they are commonly applied in fertilizers for field vegetable production. Plant nutrient recommendations are often given as pounds of N, pounds of phosphate ( $P_2O_5$ ) and pounds of potash ( $K_2O$ ) per acre.

It is up to growers to figure how much fertilizer or product they must apply to meet the suggested recommendations. This can be tricky, because growers may need more than one kind of fertilizer product to meet the recommendations.

Fertilizer products are required to list the percent N,  $P_2O_5$ , and  $K_2O$  equivalent they contain — and the products are listed in the order: N-P-K. For example, a fertilizer labeled 10-10-10 contains the equivalent of 10 percent N, 10 percent  $P_2O_5$ , and 10 percent  $K_2O$ . So a pound of this fertilizer would contain 0.1 pound each of N,  $P_2O_5$ , and  $K_2O$ . Urea labeled 46-0-0 contains 46 percent N, 0 percent  $P_2O_5$ , and 0 percent  $K_2O$ . Potassium chloride (muriate of potash) labeled 0-0-60 contains 0 percent N, 0 percent  $P_2O_5$ , and 60 percent  $K_2O$ . Organic fertilizers are also labeled this way — a 3-2-2 product contains 3 percent N, 2 percent  $P_2O_5$ , and 2 percent  $K_2O$ . It's important to note that some of the N and P in organic fertilizers require warm, moist soil and microbial activity before it is available to plants.

Let's say a nutrient recommendation calls for 100 pounds of N and 100 pounds of  $K_2O$  per acre.

A grower could meet that recommendation by using 217 pounds of urea (217 pounds of urea X 0.46 N = 100 pounds of N) and 167 pounds of potassium chloride (167 pounds of potassium chloride X 0.60  $K_2O$  = 100 pounds of  $K_2O$ ).

A grower could also meet that recommendation by using 1,000 pounds of premixed 10-10-10 fertilizer (1,000 pounds of fertilizer X 0.10 N = 100 pounds of N; 1,000 pounds of fertilizer X 0.10  $K_2O$  = 100 pounds of  $K_2O$ ).

But that same fertilizer would also supply 100 pounds of  $P_2O_5$  that is not needed. So using such a fertilizer could be a waste of money and could pollute surface or ground water.

If you choose a premixed fertilizer, select the ratio of nutrients that comes closest to the amount of recommended nutrients. It is not necessary to be exact as long as any differences are reasonable. If you can't get to the recommended nutrient application using premixed fertilizers, it is fine to first make a base application using a standard fertilizer ratio, and then apply individual elements to reach the recommended nutrient levels.

For example, you can supply extra N with urea or urea ammonium nitrate (UAN) solution; you can supply extra K with muriate of potash. Custom-blended fertilizers can be made to almost any desired ratio.

## **Nitrogen (N)**

Standard soil tests aren't very useful for predicting how much N fertilizer you need to apply to optimize yield and quality. N fertilizer recommendations account for the soil type, amount of organic matter in the soil, field history, and crop. The recommendations in this guide are based on data from relevant field trials. Adjust these recommendations according to experience, soil type, cropping history, additions of organic matter, and crop culture system.

For example, suppose your vegetable crop is following soybeans, alfalfa, or a grass-legume hay crop. If your soils have more than 3 percent organic matter, you may not need to add any sidedressed N. If your soils that have less than 3 percent organic matter, then half the total N can be applied preplant and the other half sidedressed early in the crop growth cycle.

Now suppose your vegetable crop is following corn, rye, oats, wheat, or a previous vegetable crop. There may be no residual soil N available, so the crop may benefit from additional sidedress N. It may be useful to test the soil for nitrate-N shortly before sidedressing to assess whether the crop will benefit from the application.

## **Phosphorus (P)**

P recommendations for vegetables are based on the soil test value, the type of crop, and estimates of crop removal. On mineral soils, most vegetables will benefit from P fertilization if the soil test is less than 35-40 ppm P using the Bray-Kurtz P1 extraction method.

If the soil test on a mineral soil is more than 80 ppm P, then no additional P is recommended for most

vegetables. P does not move readily in the soil and applied P easily reacts with soil minerals so that it is unavailable to the plant. That's why P fertilizer is applied in bands near the crop when possible, and starter solutions that are high in P are recommended for transplants.

## **Potassium (K)**

K recommendations for vegetables are based on the soil test value, the soil CEC, the type of crop, and estimates of crop removal.

Vegetables usually benefit from K fertilization if the soil test is:

- Less than 85 ppm K on a soil with low CEC (4 meq/100 g).
- Less than 115 ppm K on a soil with medium CEC (16 meq/100 g).

The maximum annual K recommendation for most vegetables is 300 pounds of  $K_2O$  per acre. K fertilization is not usually recommended if the soil test is more than 135 ppm K on a soil with low CEC, or more than 165 ppm K on a soil with medium CEC.

## **Micronutrients**

Micronutrients include boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn). Of these 11 nutrients, those most likely to be lacking in Midwest soils used for vegetable production are Ca, Mg, B, and Mn. S and Zn may also be a concern in some areas.

## **Calcium (Ca), Magnesium (Mg), and Sulfur (S)**

Ca and Mg usually are deficient on acid soils. Adding calcitic or dolomitic lime solves most Ca and Mg deficiency problems (see Liming and Soil pH, page 17). When Ca is deficient and there is no need to increase soil pH, you may use gypsum as a source of Ca. Similarly, you can add Mg without affecting pH by using Epsom salts (magnesium sulfate, 10 percent Mg), sul-po-mag (11 percent Mg), or finely ground magnesium oxide (e.g., MAGOX®, 58 percent Mg).

If a soil test shows low Mg (less than 50 ppm in Minnesota or less than 40 ppm in other states), apply Mg at 100 pounds per acre broadcast or 20 pounds per acre in the row.

If a soil test shows medium Mg (51-100 ppm in Minnesota or 40-69 ppm in other states) apply Mg at 50 pounds per acre broadcast or 10 pounds per acre in the row.

If a soil test shows high Mg, no application is necessary. You can make foliar sprays of Epsom salts at the rate of 10 to 15 pounds in a least 30 gallons per acre to temporarily solve Mg deficiencies during the growing season.

If a soil test indicates a need for sulfur, materials such as gypsum (calcium sulfate), Epsom salts (magnesium sulfate), ammonium sulfate, potassium sulfate, potassium-magnesium sulfate can be used. Make sure to account for the nutrients in addition to sulfur that these materials supply.

## **Manganese (Mn)**

Mn deficiency is common in some areas. Mn deficiency occurs primarily on lakebed and fine-textured, dark-colored soils with high pH. Cool, wet conditions tend to intensify Mn deficiency. Beans, beets, onions, spinach, and tomatoes have high requirements, but deficiencies also are reported for cucumbers, peppers, and turnips.

Apply manganese sulfate at 2 to 4 pounds per 100 gallons per acre to eliminate deficiency problems observed during the growing season. Fungicides containing Mn can also help correct deficiencies.

## **Boron (B)**

B leaches readily, so responsive crops often need annual applications on sandy loam, loamy sand, sandy, and muck soils. Deficiency symptoms include browning on cauliflower heads, cracked stems on celery, blackheart on beet, and internal browning on turnip.

Broccoli, cauliflower, celery, beet, turnip, and rutabaga are likely to respond to B applications of 3 to 4 pounds per acre when soil levels are low. Cabbage, carrot, lettuce, parsnip, radish, spinach, and tomato show a medium response and usually benefit from 1 to 2 pounds of B per acre.

Bean, peas, and cucumber are sensitive to B, so do not apply it to these crops.

You can add B to the soil with Borax® (which contains 10.6 percent B) or Solubor® (which contains 20.5 percent B). B applications are most effective if applied with the fertilizer at preplant or at the time of transplanting.

Mid- or late season foliar applications are not as effective as early granular or foliar applications. It is important not to exceed recommended B rates to avoid toxicity in subsequent B-sensitive crops. Carryover is most likely after a dry fall and winter.

Other micronutrient deficiencies are rare in field-grown vegetable crops in this region.



Test your soil each year before deciding what fertilizers to add.

## Fertilizer and the Environment

Nitrogen from both natural (manure, compost, green manure) and synthetic sources can be lost from fields, which can pollute water and increase greenhouse gasses that contribute to climate change. Similarly, natural and synthetic sources of P can move out of cropped areas and pollute waterways. With proper fertilizer management, vegetable producers can minimize environmental impacts and improve fertilizer use efficiency. Growers should know their crops, account for the nutrient values of all soil amendments, and test soils and plants to support their fertilizer decisions.

Split N applications — applying some N before planting and sidedressing the rest during the season — are generally more efficient than complete preplant applications. However, split applications require growers to pay attention to crop growth and sidedress at the appropriate times: before crops are stressed, and early enough to allow crops to mature.

Banding P at planting (with or without some P being broadcast/incorporated) is generally more efficient than broadcasting all P. Sidedressing P is not recommended because it is not mobile in soils.

Generally, K and the minor elements do not contribute significantly to groundwater pollution, but growers should manage them properly to minimize costs and maximize efficiency.

Minimizing soil erosion, timing irrigation properly, and avoiding excess irrigation will also improve fertilizer use efficiency and reduce losses from the field.

## Fertilizer Application Methods

Fertilizer application timing and methods vary from farm-to-farm depending on cultural practices and equipment. This section outlines common practices of efficient fertilizer placement and utilization. These practices can be modified to suit particular situations.

Usually, growers can apply at preplant and disk into the soil 50-60 percent of the recommended N and all of the P and K fertilizer. This is especially true when the rates of a complete fertilizer will require more than 400 pounds per acre.

We recommend band application for many direct-seeded vegetable crops. This technique applies a concentrated line of fertilizer 2 inches to the side and 2 inches below the seed furrow. This is an efficient way to apply fertilizer, and much of the P and K fertilizer can be applied this way. However, do not make banded fertilizer applications

exceeding 80 pounds per acre of N plus K — this can injure seed.

For crops grown on plastic mulch (with or without a raised bed) growers may apply fertilizer just to the bed area. As with broadcast applications, growers can apply a portion of the recommended N, and all of the P and K before planting. If N will be supplied through fertigation during the season, apply only 20 to 50 percent of the total N before planting. Apply the remaining N with regular drip irrigation at 5 to 10 pounds of N per week until the total recommended for the season has been applied.

If you apply only part of the recommended N before planting, apply the remainder as a sidedressing when the plants are still young, or apply N through fertigation before and during the period of rapid crop growth. Early sidedress applications are especially important with crops such as sweet corn, broccoli, and cabbage. The total N applied during the growing season (broadcast, plus banded, plus transplant starter, plus sidedressed, plus fertigated) should equal the recommended N rate. Applying more than the recommended rate of N may be necessary when there are leaching rains.

Transplanted crops often respond to a small amount of water-soluble fertilizer in the transplanting water. Special fertilizer grades (such as 14-28-14, 10-52-10, 23-21-17) are used at a rate of 3 pounds per 50 gallons of water. The high-P liquid 10-34-0 can also be used at the rate of 2 quarts per 50 gallons of water. Apply starter solutions at 8 ounces per plant. If dry weather is prevalent, irrigate after setting the plants.

## Fertilizer Rates per Linear Bed Foot

You can apply fertilizer in a band while shaping beds or laying plastic. You can also apply it dissolved through irrigation water and delivered by drip tape to the base of the plants. In these systems, it is helpful to calculate the fertilizer rate per linear bed foot (LBF) based on the fertilizer rate per acre. To do so, you will need to know:

- Bed spacing (BS): distance in feet between the centers of beds
- Fertilizer rate in lb./A (RatePerA)

Use this equation to determine the fertilizer rate in pounds per LBF:

$$(RatePerA \times BS) \div 43,560 = RatePerLBF$$

## Rate per Linear Bed Foot for Various Bed Spacings and Rates

Bed Spacing (ft)	Linear Bed Feet (LBF) in 1 Acre	Fertilizer Rate (lbs./A)							
		20	40	60	80	100	120	140	160
Fertilizer Rate (lb./LBF)									
3	14,520	0.0014	0.0028	0.0041	0.0055	0.0069	0.0083	0.0096	0.011
4	10,890	0.0018	0.0037	0.0055	0.0073	0.0092	0.011	0.0129	0.0147
5	8,712	0.0023	0.0046	0.0069	0.0092	0.0115	0.0138	0.0161	0.0184
6	7,260	0.0028	0.0055	0.0083	0.011	0.0138	0.0165	0.0193	0.022
7	6,222	0.0032	0.0064	0.0096	0.0129	0.0161	0.0193	0.0225	0.0257
8	5,445	0.0037	0.0073	0.011	0.0147	0.0184	0.022	0.0257	0.0294
9	4,840	0.0041	0.0083	0.0124	0.0165	0.0207	0.0248	0.0289	0.0331
10	4,356	0.0046	0.0092	0.0138	0.0184	0.023	0.0275	0.0321	0.0367

Example:

Bed spacing (BS) = 5 ft. between centers of beds

Fertilizer rate in lb./A (RateperA) = 100 lbs./A

$$(100 \times 5) \div 43,560 = 0.0115 \text{ lb. per LBF}$$

For a crop on six 100-foot beds, there would 600 LBF to fertilize. The amount of fertilizer needed to supply 100 lbs./A would be: 600 LBF X 0.0115 lb./LBF = 6.9 lbs.

The Rate per Linear Bed Foot for Various Bed Spacings and Rates table provides conversion of lb./A to lb./LBF for a number of bed spacings and fertilizer rates.

## Liming and Soil pH

Soil pH describes whether the soil solution is acidic or alkaline. The native pH of Midwest soils varies from quite acidic (pH 5.0 or lower) to quite alkaline (pH 7.5 or higher). Most vegetable crops prefer a pH range of 6.0-6.8 on mineral soils. On muck soils, a pH of 5.5-5.8 is considered adequate. Vegetables grown under acid soil conditions lack vigor and yield poorly. Acid soils restrict the uptake of nutrients such as P and K. Acid soils also make elements such as aluminum (Al) and manganese (Mn) more available to plants so that the plant may absorb enough to be toxic to the plant. Under severe conditions, visible foliage injury can result from magnesium (Mg) deficiency and/or Mn toxicity. Physiological disorders such as blossom end rot are

more common on acid soils. In contrast, when soil pH is high, Mn, B, iron (Fe), and certain other micronutrients become less available for plant uptake. Deficiencies of these micronutrients are most likely to occur on mineral soils with pH greater than 7.4.

Lime neutralizes soil acidity and supplies Ca and Mg, elements necessary for plant growth. A soil test determines how much lime you need. Liming may be necessary every few years because soil pH tends to decline over time. The decline is caused by synthetic N fertilizers, the crop's removal of Ca, and the leaching of Ca and Mg by rain.

## Soil pH and Plant Nutrients

### Nitrogen (N)

Plants can take up N in the form of ammonium ( $\text{NH}_4^+$ ) or nitrate ( $\text{NO}_3^-$ ). In the soil, ammonium is converted into nitrate, and vice versa, by a particular set of microbes. When soil pH is near neutral (pH 7), and the soil is moist and warm, the microbial conversion of ammonium to nitrate (nitrification) is rapid, and crops generally take up nitrate. In acid soils (pH lower than 6), nitrification is slow, and plants will take up a higher percentage of N as ammonium.

Soil pH also plays an important role in N loss due to volatilization. Volatilization occurs when N compounds turn to gaseous forms (ammonia, nitrous oxides, N

gas) and evaporate into the air. Ammonium in the soil solution exists in equilibrium with ammonia gas ( $\text{NH}_3$ ). The amount of each compound depends to a large extent on the soil pH. At lower pH, there is more ammonium and less ammonia gas. At pH 7, the equilibrium condition is 99 percent ammonium and 1 percent ammonia. At pH 8, the equilibrium is about 90 percent ammonium and 10 percent ammonia gas.

Volatilization from N fertilizers that contribute ammonium to the soil (such as urea) is likely to be high at higher soil pH levels. However, depending on soil temperature and moisture, volatilization can be significant at lower soil pH levels, too, especially if the soil is dry and the fertilizer is not incorporated. To minimize volatilization, apply N in just the quantities plants need during the growing season, incorporate it into the soil, and use slow-release sources when possible.

Soil pH is also an important factor in the N nutrition of legumes. Plants in this family are able to fix N from the soil with the help of several Genera of soil bacteria known collectively as *Rhizobia*. As soils become more acidic, *Rhizobia* decline in activity, fixing less N.

### **Phosphorus (P)**

Plants absorb P from the soil solution in the form of soluble phosphates. At any time, the amount of P in solution is usually extremely low — often less than 1 pound per acre — because P joins with other elements in the soil to form stable minerals.

The type of mineral that gets formed in the soil depends on the soil's pH. In alkaline soils, P in fertilizers such as mono-ammonium phosphate (11-55-0) usually react with Ca to form calcium phosphate minerals. The P in calcium phosphate minerals is not available to plants, but as plants remove P from the soil solution, the minerals gradually dissolve to replenish the supply of P in the soil solution. Greenhouse and field research has shown that more than 90 percent of the fertilizer P tied up this year in calcium phosphate minerals will be available to crops in future years.

In acid soils, P usually reacts with Al and Fe, instead of Ca. Aluminum and iron phosphates do not dissolve as readily as calcium phosphates, so in acid soils, applied P tends to be tied up more than in alkaline soils.

### **Potassium (K)**

In soils with certain types of clay, K is fixed at specific sites between clay layers. This tends to be reduced under acid conditions, presumably because Al occupies the binding sites that would otherwise trap K. Because of this, one might think that raising the pH by liming

would reduce the availability of K. However, this is not the case — at least in the short term. Liming increases K availability, probably because Ca displaces K on exchange sites.

### **Sulfur (S)**

Plants absorb sulfur as sulfate ( $\text{SO}_4^{2-}$ ). Sulfate is little affected by soil pH.

### **Micronutrients**

Micronutrients are elements plants need in very small amounts. The availability of the micronutrients — Mn, Fe, copper (Cu), Zn, and B — decreases as soil pH increases. The exact mechanisms responsible for reducing availability differ for each nutrient. Micronutrient deficiencies are more likely at high pH, and toxicities are more likely at low pH.

The availability of molybdenum (Mo) is reduced under acid conditions. Mo deficiency is more likely to occur in acid soils.

### **Summary**

Soil pH plays an important role in nutrient availability. If soil pH is too high or too low, it is difficult to properly balance the nutrients required for good crop growth. Manage soil to keep its pH in the acceptable range. Be aware of soil pH and its influence on nutrient availability as you make a nutrient management plan and during crop production.

### **Types of Lime**

Several types of lime that may be used to manage soil pH and/or Ca and Mg are described below. After each discussion, the percentage of CaO and MgO in a typical batch of lime is given.

Calcitic lime (also called high-calcium lime — 50-56% CaO, 1-4% MgO) is the most soluble form and is the preferred type when soil Ca is low and soil Mg is high. It generally reacts the fastest and is the most common form available in some areas.

Magnesian lime (also called hi-mag lime — 32-42% CaO, 5-15% MgO) is intermediate in solubility and is the preferred type when pH, Ca, and Mg are low. The continued use of high-Mg liming materials increases the base saturation of Mg and decreases Ca saturation, which may result in Ca deficiencies during stress periods.

Dolomitic lime (30% CaO, 20% MgO) is the preferred type when Mg is particularly low. Dolomitic lime is the least soluble of the materials.

Hydrated lime (60% CaO, 12% MgO) reacts most rapidly with the soil, but unlike the ground limestones described above, it does not continue to provide liming activity over a period of years. Hydrated lime is caustic to humans and plants, and applicators must take care not to burn plants. Use hydrated lime only in emergencies when rapid changes in soil pH are needed.

Gypsum is not a liming material and does not affect soil pH. It is a crude calcium sulfate product consisting chiefly of calcium sulfate with combined water ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ). Although gypsum is not capable of neutralizing soil acidity, it is a source of calcium and sulfur.

Fluid lime is a suspension of finely ground limestone in water, and may contain other dispersing agents. Finely ground limestone reacts with soil more quickly than normal limestone. In fluid lime, 100 percent of the liming material must pass through a 100-mesh screen, and nearly 80 to 90 percent must pass through an even smaller 200-mesh screen. The principles of effectiveness of ground agricultural lime also apply to fine or fluid lime. Lime suspensions do not possess any special capabilities compared with conventional agricultural lime that contains a high degree of 60-mesh or finer particles.

Pelletized lime, or pell-lime, is finely ground lime that has been formed into pellets for easy application. Because it is finely ground, it will react quickly in the soil. Unlike regular ag lime, it will not provide residual liming activity over a few years.

## Lime Recommendations

Fields usually require lime every few years because Ca and Mg are removed in harvested portions of the crop, leached out of surface soil by rainfall, and lost from the field when soil erodes. Lime is also needed to neutralize acidity produced by acid-forming fertilizers.

Growers sometimes need to add lime to correct subsoil acidity. In that case, apply enough lime to bring the surface soil to pH 6.8. The subsoil pH will increase only if you maintain the surface pH near 6.5 or more. Over time, rain will leach the Ca and Mg into the subsoil, raising its pH. Because this downward movement takes several years, the sooner the lime is applied, the better.

In most cases, make split applications when the recommendation is more than 4 tons per acre. This will achieve a more thorough mixing with the acidic soil. Apply half the lime before plowing and half before soil tilling. For best results, apply the lime at least six months before seeding a legume.

If you have a recommendation for a maintenance application of 2 tons per acre or less, you can apply it at any time in the cropping sequence.

## Plant Tissue Analysis

Plant tissue analysis for nutrients is a useful tool in managing plant health, and a tissue test is usually required to confirm the diagnosis. Tissue testing can be especially helpful when growing a new crop or a familiar crop in a new production system.

Regular tissue tests, especially early in the growing season, will provide early notice of nutrient imbalances so they can be corrected before yield or quality is affected. With high value greenhouse crops regular tissue testing is often a standard part of production.

Concentrations of nutrients in plant tissue that are normal, deficient, or excessive have been identified for most vegetables. The concentrations depend on the plant part and stage of growth. Before collecting plant tissue, contact a tissue testing lab and request instructions for collecting and submitting samples. The specific plant part to collect for tissue analysis varies depending on the crop; often it is a young mature leaf. The stage of crop growth is important because normal tissue nutrient concentrations change as the crop develops.

If the tissue test is being used to diagnose a specific symptom, collect separate samples from each of these groups:

- Symptomatic plants
- Healthy plants
- Plants with minor symptoms

Comparing the results of these three samples, along with results of soil tests, can help in determining the problem. For assistance in interpreting plant tissue tests, contact your local extension vegetable specialist.

## Chemigation Management

Chemigation is the process of applying an agricultural chemical (pesticide or fertilizer) to the soil or plant surface through an irrigation system. Depending on the type of agricultural chemical, chemigation may be referred to as fertigation, insectigation, fungigation, etc.

For chemigation applications, you can only use pesticides that display EPA approval for such applications on the label. Each chemigation and irrigation system also must

use the safety equipment specified on the EPA label as well as any equipment required in your state. Some states also may require a system or operator permit before you can apply any product with chemigation.

Chemigation can be an effective application option for some labeled pesticides if the irrigation system can apply the chemical/water solution uniformly over the target area with the correct water depth. Some pesticides work best with less than 0.25 inch of water per application. Most late-model center pivot and linear move systems provide adequate distribution but some may not be able to apply a small enough volume of water. Solid set sprinkler systems may be effective for some pesticides but require close timing of chemical movements to get complete and uniform coverage of the field. Traveling gun and hand move systems do not provide water distribution that has high uniformity and are not recommended. Product labels provide more information about appropriate water application amounts and which irrigation systems are recommended.

If you do not have or maintain proper check valves and interlocks, the injected chemicals could backflow into the water source. EPA and many state regulations specify that each system must contain a reduced pressure zone (RPZ) backflow prevention valve or one or two independent check valves with low-pressure drains and vacuum relief valves between the irrigation water source and the point of chemical injection. Also, most regulations require a power interlock between the irrigation pump and the chemical injector unit, a low pressure shut down switch and a check valve on the chemical injection hose. For specific requirements, check with the appropriate local or state agency.

It is important to accurately calibrate the irrigation system and pesticide application rate. The chemigation operator must be aware of the irrigation system's application speed (acres per hour) for the chosen water application amount and the concentration of chemical solution to determine the rate of chemical injection.

More information about the special equipment, operations, and calibration is available in the University of Minnesota Extension Service bulletins, WW-06122, *Chemigation Safety Measures*, and WW-6118-GO, *Nitrogen Application with Irrigation Water*, available at [www.extension.umn.edu](http://www.extension.umn.edu).

## **Organic Matter and Cover Crops**

Organic matter affects plant growth and frequently is referred to as the "glue" that holds soil particles together. It also promotes the development of soil aggregates, thus improving drainage, soil tilth, and soil structure. In sandy and sandy loam soils, organic matter improves water-holding capacity.

You can add organic matter to the soil by various methods using green manure crops, cover crops, crop residues, animal manures, mulches, and composts. Green manure crops include sweet clover, alfalfa, thickly sown field corn, and summer seedings of soybean. These crops generally are plowed under before they are mature. At this stage, the plants usually contain the greatest amount of N and other nutrients, plus an adequate amount of moisture for rapid decay. However, green manure crops also can be plowed under in the mature dry stage. At that stage, they do not decompose as readily and additional N may be needed to aid decomposition.

Typically, growers plant cover crops after harvest to protect the soil against erosion and usually turned the cover crops over the following spring. Additional N may be needed to hasten the decomposition of the cover crop. This is especially important with rye, which should be plowed under before it is 18 inches tall.

Different cover crops frequently require special soil conditions for optimum growth. For example, alfalfa requires well-drained soils, while Ladino clover grows on poorly drained soils. Some crops, such as rye, have fibrous root systems, whereas others (sweet clover) have large taproots that can penetrate the soil to considerable depths. Whenever it is possible to use a mixture of these crops, the combination results in more organic matter to plow under.

## Examples of Integrating Cover Crops

Cover crops help add organic matter, manage soilborne diseases, and avoid soil erosion. Below are examples of five four-year cropping sequences that you can use with vegetable crops. Each cover crop rotation sequence is designed to take advantage of legumes for N-fixation, grass or buckwheat to suppress weeds, and brassica cover crops for bio-fumigation and reducing soil compaction.

These rotations won't work on every farm. Growers should try likely rotations in manageable areas to develop the best strategy for their farms. Learn the characteristics of the cover crops and cropping sequences by checking with an extension specialist or by visiting the Midwest Cover Crops Council website, [www.mccc.msu.edu](http://www.mccc.msu.edu).

Green Manure Crops for Vegetable Farms (page 23) describes a few useful characteristics of cover crops that may be used for vegetable crops. For more information about cover crops, contact your state extension service or visit the Midwest Cover Crops Council website, [www.mccc.msu.edu](http://www.mccc.msu.edu).

### Example 1

*Fall before Year 1:* Plant oats and peas as cover crops

#### Year 1

*March:* Leave winter-killed field peas

*April-August:* Onion production

*August-November:* Crimson clover as a cover crop

#### Year 2

*March:* Leave winter-killed crimson clover

*April-August:* Potato production

*August-November:* Sorghum-sudangrass as a cover crop

#### Year 3

*March-May:* Leave winter-killed sorghum-sudangrass

*May-October:* Sweet potato production

*October-June of Year 4:* Cereal rye as a cover crop

#### Year 4

*June-September:* Cucumber production

*September-November:* Oats and field peas as a cover crop

#### Year 5

Return to Year 1

### Example 2

*Fall before Year 1:* Cereal rye and hairy vetch as cover crops

#### Year 1

*March-June:* Leave cereal rye and hairy vetch

*April-November:* Pumpkin production

*November-May of Year 2:* Cereal rye as a cover crop

#### Year 2

*March-May:* Leave cereal rye as cover crop

*May-September:* Broccoli production

*September-November:* Buckwheat as a cover crop

#### Year 3

*March:* Leave winter-killed buckwheat

*April-August:* Carrot production

*August-November:* Crimson clover as a cover crop

#### Year 4

*March-May:* Leave winter-killed crimson clover

*May-September:* Sweet corn production

*September-November:* Cereal rye and hairy vetch as cover crops

#### Year 5

Return to Year 1

### Example 3

*Fall before Year 1:* Oilseed radish as cover crop

#### Year 1

*March:* Leave winter-killed oilseed radish

*April-July:* Lettuce production

*July-August:* Buckwheat as cover crop

*August-November:* Cauliflower production

*November-June of Year 2:* Cereal rye as a cover crop

#### Year 2

*March-June:* Leave cereal rye cover crop

*June-October:* Eggplant or pepper production

*October-May of Year 3:* Triticale as cover crop

### **Year 3**

*March-May:* Leave triticale

*May-September:* Onion production

*September-November:* Oats and field peas as cover crops

### **Year 4**

*March-May:* Leave winter-killed oats and field peas

*May-September:* Cucumber production

*September-November:* Oilseed radish as cover crop

### **Year 5**

Return to Year 1

### **Example 4**

*Fall before Year 1:* Cowpea as cover crop

### **Year 1**

*March-May:* Leave winter-killed cowpea

*May-August:* Sweet corn production

*August-October:* Buckwheat as cover crop

*October-August of Year 2:* Garlic production

### **Year 2**

*March-August:* Leave garlic

*August-November:* Sorghum-sudangrass as cover crop

### **Year 3**

*March-June:* Leave winter-killed sorghum-sudangrass

*June-November:* Pumpkin or winter squash production

*November-April of Year 4:* Cereal rye as cover crop

### **Year 4**

*March:* Leave cereal rye cover crop

*April-July:* Potato production

*July-November:* Cowpea as cover crop

### **Year 5**

Return to Year 1

### **Example 5**

*Fall before Year 1:* Yellow mustard as cover crop

### **Year 1**

*March-May:* Leave winter-killed mustard

*May-September:* Cantaloupe production

*September-June of Year 2:* Cereal rye and hairy vetch as cover crops

### **Year 2**

*March-June:* Leave cereal rye and hairy vetch cover crops

*June-October:* Sweet potato production

*October-April of Year 3:* Triticale as cover crop

### **Year 3**

*March:* Leave triticale cover crop

*April-July:* Cauliflower production

*July-August:* Buckwheat as cover crop

*August-November:* Lettuce or spinach production

*November-May of Year 4:* Cereal rye as cover crop

### **Year 4**

*March-May:* Leave cereal rye cover crop

*May-September:* Pepper production

*September-November:* Mustard as cover crop

### **Year 5**

Return to Year 1

## Green Manure Crops for Vegetable Farms

Seeding Crop Number	Pounds/Bushel	Quantity of Seed per Acre (pounds)	Desirable Seeding Dates
<b>Nonlegumes</b>			
Rye	60	90-120 (alone) 90 (mixture)	Sept. 1-Nov. 10
Perennial or common ryegrass	24	15-20 (alone) 5-8 (mixture)	Aug. 1-Sept. 15
Sudangrass	40	20-30	May 15-July 1
Field corn	56	50-60	May 15-July 1
Winter barley	48	80-100	2-3 weeks before fly-safe date
Wheat	60	90-120	Hessian fly-safe date
<b>Legumes</b>			
Sweet clover	60	16-20 (alone) 10-12 (mixture)	March 1-April 15 July 15-Aug. 20
Red clover	60	10-15 (alone)	Feb. 1-April 1
Soybean	60	90-100	May 15-July 1
Alfalfa	60	12-18	March-April
Hairy vetch	60	15-20 (mixture)	Sept. 1-Nov. 1
<b>Mixtures</b>			
Rye/vetch		90/15-20	Sept. 1-Oct. 1
Ryegrass/sweet clover		5-8 12-15	July 15-Aug. 20
Sweet clover/orchardgrass		6-8	March 1-April 15

## Animal Manures and Composts as Fertilizers

Animal manures and composts can provide significant nutrients to plants. The nutrient content of manures varies among animal species and within each species. Nutrients in composts can vary even more and depend on parent material and processing. Test manures and composts to determine the potential nutrient contributions and application rates. Avoid using composts made of unknown origin or parent material. Improperly made composts, be they of rural or urban origin, can contain heavy metals, inorganic debris, diseases, and insects that are unwelcome on your fields.

It is important to consider the timing of manure and compost applications. Fresh manure has potential to “burn” a crop because it often contains high levels of ammonia, and fresh or casually “aged” manure often contains human pathogens. For these reasons, it is rarely acceptable to apply fresh or “aged” manure to food crops while they are growing. Generally, a fall application is acceptable, ideally to a cover crop, and at least nine months before harvesting the next vegetable crop. Manure that has been properly composted and then

protected from contamination is less likely to contain human pathogens and may be used closer to harvest if steps are taken to minimize contact with the food crop. Any use of manure or composts should follow current Good Agricultural Practices (GAPs) or the demands of a particular market, if more stringent. For guidance about current GAPs from the U.S. FDA, see [www.fda.gov/food/guidanceregulation/fsma/ucm253380.htm](http://www.fda.gov/food/guidanceregulation/fsma/ucm253380.htm).

## Transplant Production

Transplant production has replaced direct seeding for many vegetable crops. One of transplanting’s primary advantages is earlier fruit production, allowing growers to capture better market conditions. In addition, the high cost of hybrid seed makes it desirable to use each seed as efficiently as possible. Transplanting also gives the crops a competitive advantage against weeds. This section addresses the special skills and knowledge required for successful transplant production.

Most growers use polyethylene-covered greenhouse structures to provide warmth and protection from the environment. Although cole crops do not need the more

moderating conditions a greenhouse provides, they can be grown in coldframes, lean-tos, or covered wagon beds.

The heater is one of the most critical features of a transplant greenhouse. Vegetable transplants must be kept at the appropriate temperatures. However, if heaters are improperly exhausted, the transplants can be stunted or deformed. To prevent heater fumes from returning into the greenhouse, chimneys should extend two feet above the ridge of the greenhouse.

There should be some provision for bringing fresh air into the greenhouse. Some heaters vent fresh air into the greenhouse every time the furnace operates. For others, a hole or holes should be cut in the greenhouse wall and fitted with tubes to feed outside air to the heater. Avoid space heaters that may “spit” diesel or gasoline onto nearby plants. Heated air should be circulated using a perforated “sock” or tube that runs the length of the greenhouse, or fans placed on opposite sides of the greenhouse and blowing in opposite directions. Place thermometers in several locations to measure the temperature at plant level. At least one high-low thermometer is a good investment.

For detailed information about greenhouse structures, see *Greenhouse Engineering* (NRAES-33), available from Plant and Life Sciences Publishing: [palspublishing.cals.cornell.edu](http://palspublishing.cals.cornell.edu).

## Transplant Containers

A wide variety of transplant containers are available, each with advantages and disadvantages. The most common ones are:

1. Todd planter trays made of Styrofoam (Speedling type).
2. Polystyrene or PVC flats or trays.
3. Peat strips, pots or pellets (e.g., Jiffy).

Peat pot containers have the advantage that the root system need not be disturbed upon planting. Peat pots also are more forgiving of overwatering than other containers. If peat pots are planted partially above ground, moisture is “wicked” away from the plant, often resulting in plant death — peat pellets do not have this disadvantage.

Polystyrene and Todd planter flats are both designed so that transplants must be “popped” out of the trays, thus disturbing the root system. This is particularly true if the roots are allowed to grow into the ground beneath the tray. Avoid this problem by raising the flats off the ground. Both the polystyrene and Todd planter flats must be watered with care. Todd planter flats have a pyramidal design that forces roots downward to an open

bottom where the roots are air pruned. Some polystyrene containers have open bottoms — tube types have open bottoms, groove types have small drainage holes.

In general, peat type containers are the most expensive, followed by the Todd planter type, then the polystyrene type.

The number of plants in a tray depends on the cell size for each plant. Vegetables are commonly grown in trays with 30 to 300 cells. In general, larger cells lead to greater early yield in fruiting crops. Larger cells are also easier to manage because the greater soil volume holds more water and nutrients. Due to the expense of building and maintaining greenhouse space, many growers have moved to smaller cell volumes so more transplants can be grown in the limited space available. Some growers use two different cell sizes: a larger size for crops they expect to harvest earlier, and a smaller size for crops they expect to harvest later.

## Seeding and Growing

Most vegetable transplants are sown one seed per cell. As a general rule, plant vegetable seeds at a depth two times their diameter. Vegetable seeds temperature requirements vary; most vegetable seeds germinate in the 70°F to 90°F range. The time from seeding to transplanting varies from three to four weeks (e.g., cantaloupe) to 10 to 12 weeks (e.g., celery).

Vegetable seed may be ordered with special features, including seed priming and pelletizing. Primed seeds have been partially hydrated, then dried down, resulting in earlier germination and better uniformity. Priming may be useful for hard-to-germinate seed such as triploid watermelon. Seed may be pelletized to make it easier to handle. In this process, varieties with small seeds, or irregular seeds (such as lettuce) are coated to make the seed larger and uniform in size and shape. This process makes mechanized planting easier.

The growing mix should be well-drained and free of disease-causing organisms (pathogens). Most commercial mixes fit this description and perform well. These mixes are often referred to as “soilless mixes” since they are composed primarily of peat or coconut coir, perlite or vermiculite, and sometimes bark or ash. These mixes usually come in bales or bags and have been pasteurized (sufficiently heated to kill soil microorganisms capable of causing disease problems). It is advisable to test the mix before using it to make sure the pH is within an acceptable range (between 5.5 and 6.5) and to determine the initial nutrient content of the mix.

Most mixes include a small amount of fertilizer, but transplants usually benefit from additional regular nitrogen (N), phosphorus (P), and potassium (K) fertilization once true leaves appear. Depending on the initial nutrient level in the mix, including calcium (Ca) and magnesium (Mg) in the fertilizer solution may also be advised. Soluble synthetic fertilizers (21-5-20, 20-10-20) and liquid organic fertilizers (fish emulsion) are commonly used. The best rate, frequency, and method of fertilization will depend on your potting mix and watering practices. Common alternatives include a 50 to 200 ppm N solution applied at every watering, or a 300 to 500 ppm N solution applied weekly.

To make a 100 ppm N solution, use 0.42 pounds (6.6 ounces) of a 20 percent nitrogen fertilizer for every 100 gallons of water. Over-application of ammoniacal N can be detrimental to transplants. This problem can be minimized by not over-applying N, and by using fertilizer in which most N is in the nitrate form. Check the bag label.

Transplants that are too tall and tend to fall over are often referred to as "spindly," "shanky," or "leggy." Such transplants may have low survival rates in the field. Spindly transplants are produced under low light conditions, high fertilizer rates, and/or overwatering. Cloudy weather or greenhouse structures that don't let in adequate light could be the culprits. Artificial lights could be helpful during inclement weather, but may be cost prohibitive.

Under such conditions, use a fertilizer containing a lower percentage of P. For instance, try 21-5-20 rather than 20-20-20. It is important to provide adequate P, but not too much. Under fertilization with P will produce short plants, but yields also will suffer. Hot days and cold nights favor leggy transplants. If night temperatures are equal to or higher than day temperatures, stem elongation will be reduced. It may be sufficient to lower the temperatures for a two-hour period starting at dawn.

To prepare transplants for the harsher environment of the field, it is necessary to harden them off. Transplants may be hardened off by withholding water and lowering temperatures moderately during the last week or so of growth. Some growers place transplants in wagons and wheel the transplants outside on appropriate days to get the plants used to field conditions. The transplants are wheeled back inside at night and during especially harsh weather.

After transplanting, plants should be irrigated as soon as possible. Some transplanters are equipped to irrigate plants at the time of transplanting. Otherwise, arrange to irrigate soon. Applying a small amount of starter

fertilizer in the transplant water is often beneficial. If transplants are held in the greenhouse to replace those that don't survive, remember to avoid using transplants that have begun to vine or flower.

## Diseases

Diseases that are likely to affect vegetable transplant production in the Midwest fall into two types: damping-off diseases (caused by soilborne fungi) and transplant diseases (usually associated with fungi, bacteria, or viruses that survive with seed or plant residue). These diseases can cause extensive transplant loss.

Damping-off may occur before or after seedlings emerge from the soil. Preemergence damping-off occurs when fungi infect seeds as they germinate. As infections progress, seeds rot and eventually disintegrate. Poor stands become apparent after several days or weeks.

Postemergence damping-off is usually observed in seed flats or among transplants. Fungi infect stems at or near the soil surface. The affected area of the stem takes on a water-soaked appearance and sometimes becomes constricted. Eventually, the stems are unable to maintain the structural support of seedlings, which usually collapse and die within 24 to 48 hours.

Several soilborne fungi cause damping-off on vegetables. *Fusarium*, *Phytophthora*, *Pythium*, and *Rhizoctonia* species are well known causal agents of pre- and postemergence damping-off. Control measures to prevent damping-off diseases include:

- Using uncontaminated soil mix. Use a commercially prepared soilless growing mix sold in 3 to 4 cubic foot bales or bags. A common mistake is to open a bag of "clean" soil mix and place it on a dirty floor or some other unclean surface prior to planting. Remember that your soil is only as clean as the dirtiest surface it has contacted.
- Planting seeds shallow and in warm soil.
- Using soil mixes that drain well.

Seedborne and residueborne diseases affect most vegetable crops. The pathogens (disease-causing microorganisms) survive in or on seeds or plant residues, not in soil mixes. Outbreaks of these diseases often show up as clusters of diseased plants, and symptoms often include brown lesions with yellow halos on leaves. By contrast, environmentally induced problems often occur uniformly throughout the seedlings or only in one location (for example, close to an outside wall).

Several different fungal, bacterial, or viral pathogens may be introduced into a transplant facility via contaminated seed or transplants (Common Seedborne Diseases of Vegetable Crops Frequently Grown as Transplants). Once introduced, these pathogens may continue to cause problems year after year if proper precautions are not taken.

## Common Seedborne Diseases of Vegetable Crops Frequently Grown as Transplants

Vegetable Crop	Disease
cabbage	black rot
	Alternaria leaf spot
cantaloupe	anthracnose
	gummy stem blight
cucumber	angular leaf spot
pepper	bacterial spot
squash	squash mosaic (squash mosaic virus)
tomato	bacterial canker
	bacterial speck
	bacterial spot
watermelon	anthracnose
	gummy stem blight
	bacterial fruit blotch

Several measures should be taken to minimize or prevent introducing seedborne or residueborne pathogens into a transplant facility:

- Avoid saving seed unless you are specifically trained and equipped for seed production.
- Inspect seedlings frequently while they are growing.
- Separate seedlots from one another. Save all information regarding seed purchases.
- Irrigate in the morning to ensure soil and leaf surfaces dry.
- Check fungicide and bactericide labels for specific mentions of greenhouse use when treating transplants (see the Conversions for Liquid Pesticides on Small Areas table, page 42, for liquid pesticide conversions).
- Practice good sanitation. Plant pathogens often survive in soil and plant residues. Therefore, sanitation is as important for a greenhouse as it is for a kitchen. Greenhouse floors should be as free of soil and residue as possible; plastic or cloth floor coverings provide a barrier between dirt floors and transplants. Transplant

trays and flats should be new or cleaned and disinfected before each transplant generation.

More detailed information about disease prevention and control in the greenhouse is available in Preventing Seedling Diseases in the Greenhouse (Purdue Extension publication BP-61-W), and *Commercial Greenhouse and Nursery Production: Sanitation for Disease and Pest Management*, available from the Purdue Extension Education Store (HO-250-W), [www.edustore.purdue.edu](http://www.edustore.purdue.edu).

A few chemicals are labeled for disease control in greenhouse vegetable crops. Restricted use pesticides can only be used by certified pesticide applicators who have the greenhouse certification on their applicator licenses. Restricted use pesticides are identified prominently on the label.

If a pesticide is not restricted use and is labeled for the crop in question, check the label. If it does not mention greenhouse use, then it may be used in greenhouses. Otherwise, the label may explicitly prohibit greenhouse use. Thus, a specific label for greenhouse use for some products is not required; but you must carefully read each label to be certain the greenhouse use is not prohibited. Apply according to labeled rates and timing.

Products that may be used in the greenhouse are listed in Sanitizers Approved for Wash or Process Water, page 49.

## Seed Treatments

Seed treatments are useful for preventing damping-off and some other root diseases in vegetable crops. Seed treatments can also eliminate certain pathogens carried in or on the seed.

There are two general types of seed treatment: eradicative and protective.

Eradicative seed treatments kill disease-causing agents on or within seed and are useful in controlling certain seedborne diseases.

Protective seed treatments are applied to the seed surface and protect the seed against decay and damping-off caused by soilborne organisms.

For more information, see *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens*, Ohio State University Extension Fact Sheet HYG-3085-05, [ohioline.osu.edu](http://ohioline.osu.edu).

### Hot Water Treatment

When properly used, hot water treatments kill most disease-causing organisms on or within seed. This treatment is suggested for eggplant, pepper, tomato,

cucumber, carrot, spinach, lettuce, celery, cabbage, turnip, radish, and other crucifer seed. Improper treatment can injure seed. Hot-water treatment can severely damage cucurbit seed.

Warm seed in a loosely woven cotton bag (not over half full) for 10 minutes in 100°F water. Place the warmed seed in a water bath that will constantly hold the water at the recommended temperature (see Water Bath Temperatures and Treatment Lengths below). The length of treatment and temperature of the water must be exact. After treatment, dip bags in cold water to stop heating action, and then spread seed out to dry. Always apply a protective seed treatment fungicide to hot-water-treated seed.

This treatment can injure old seed. Always test a small sample of any seed lot more than a year old by treating it, and testing for germination to determine the amount of injury, if any, that might occur.

### Water Bath Temperatures and Treatment Lengths

The water bath temperatures and treatment lengths should be followed exactly.

Seed	Temperature (°F)	Minutes
Brussels sprouts, cabbage, eggplant, spinach, tomato	122	25
Broccoli, cauliflower, cucumber, carrot, collard, kale, kohlrabi, rutabaga, turnip	122	20
Mustard, cress, radish	122	15
Pepper	125	30
Lettuce, celery, celeriac	118	30

### Chlorine Treatment

Chlorine treatment effectively removes bacterial and fungal pathogens on the seed surface. Chlorine treatment is recommended for pepper, tomato, cucurbits, and other vegetables if the seeds have not been treated by another method.

Agitate seeds in a solution of 1 quart of household bleach, 4 quarts of water, and 1 teaspoon of surfactant for 1 minute. Use 1 gallon of this disinfectant solution per pound of seed and prepare a fresh solution for each batch. After placing seed in this solution, remove, and rinse thoroughly in running tap water for five minutes. After that, spread out seed to dry. Dust the seed with Thiram 75WP® at 1 teaspoon per pound of seed.

Treat the seed near planting time, as viability may be reduced over time. Before you treat all seed, we recommend that you test a small sample of each seed lot first. Treat 50-100 seeds and see how they germinate. If they germinate well, treat the rest of the seed lot.

If you treat coated seed or seed treated with fungicide with hot water or bleach, always dispose of wastewater in an environmentally sound manner.

For more information, see *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens*, Ohio State University Extension Fact Sheet HYG-3085-05, ohiooline.osu.edu.

### Fungicide Seed Treatment

Thiram is the most common seed-protectant fungicide. Other fungicides are recommended for specific crops. These fungicides are often combined with insecticides, and these combinations may be superior to fungicide treatment alone. Purchase treated seed, or dust seed lightly with fungicide according to label directions.

**Do not use treated seed for food or feed.**

## Using Plastic Mulch

Black plastic mulch laid before planting helps control weeds, reduce root pruning, and give profitable increases in early yields of warm-season crops. Wavelength-selective and clear mulches typically lead to greater early yields than black plastic, but weed growth under these mulches may be a problem. This is particularly true for clear mulch. Because leaching is retarded, less fertilizer is lost, and nitrogen sidedressing is often unnecessary with the plastic mulch. If nitrogen needs to be added, it can be applied later through the irrigation system.

Try to lay plastic mulches as early in the season as possible. Mulches should be laid as soon as the ground can be worked after a heavy rain. Irrigate the field if soil moisture is not adequate prior to laying the mulch. Plastic mulches should be laid over moist soil. If the plastic is laid over dry soil, it will actually delay subsequent transplant growth. It is better to lay out plastic at midday so it can be stretched tight. However, do not overstretch the plastic because cool nights may actually cause it to tear.

The seedbed should be as fine as possible in order to get a good covering. The plastic is laid by burying about 6 inches of each edge. Black plastic mulch is most effective in warming the soil when it is in direct contact with the soil.

A disadvantage of plastic mulch is disposal at the end of the season. Many landfills do not accept plastic mulches. Photodegradable plastic mulches, which degrade into small pieces of plastic that remain in the environment, are available. Biodegradable plastic mulches that break down completely are available.

Yields of pepper, eggplant, and summer squash are higher most years, and harvest can be up to seven days earlier than unmulched plantings. Clear plastic mulch is common in early sweet corn production. Growers can plant sweet corn in hills, single rows, or double rows, and apply herbicides before laying the plastic. Clear plastic mulch warms the soil and contributes to early harvest and quality produce.

Herbicides that were applied before the mulch was laid may break down before the crop matures. Unless otherwise advised, never apply herbicides over the top of plastic mulch. An alternative to the clear mulch/herbicide system is the IRT or *wavelength selective mulch* system. IRT mulches provide similar soil warming to clear film while controlling most weeds like black plastic.

Apply all fertilizer before laying the plastic, but reduce the total amount applied by 10-15 percent. Mulch layers are available in various widths. They also can be adapted for raised beds and for the laying of trickle irrigation tubes all in one operation.

Trickle irrigation combined with plastic mulch offers several advantages: it uses water economically, requires less energy for pumping, wets leaf surface less, allows for easy fertilizer application, provides a uniform moisture supply, and allows the application of certain insecticides and fungicides.

## Irrigation and Water Management

Vegetables require an adequate supply of moisture throughout their entire growth. While the frequency and amount of water varies according to individual vegetable crop, its age, current soil moisture, soil type, and weather conditions, generally 1 to 1.5 acre inches of water are required each week.

## Effective Rooting Depth of Selected Vegetables

Shallow (6-12 inches)	Moderate (18-24 inches)	Deep (> 36 inches)
Beet	Cabbage, Brussels sprouts	Asparagus
Broccoli	Cantaloupe	Lima bean
Carrot	Cucumber	Pumpkin
Cauliflower	Eggplant	Sweet potato
Celery	Pea	Watermelon
Greens & herbs	Potato	Squash, winter
Onion	Snap bean	
Pepper	Squash, summer	
Radish	Sweet corn	
Spinach	Tomato	

## Vegetable Crops and Growth Period Most Critical for Irrigation Requirements

Crop <sup>1</sup>	Most Critical Period
broccoli, cabbage, cauliflower, lettuce	head development
carrot, radish, beet, turnip	root enlargement
sweet corn	silking, tasseling, and ear development
cucumber, eggplant, pepper, melon, tomato	flowering, fruit set, and maturation
bean, pea	flowering, fruit set, and development
onion	bulb development
potato	tuber set and enlargement

<sup>1</sup>For transplants, transplanting and stand establishment represent a most critical period for adequate water.

The total available water holding capacity (AWHC) for a given location depends on soil texture, organic matter, and rooting depth. AWHC estimates are best obtained from the county soil survey or the local Soil and Water Conservation District office. Available Water Holding Capacities for Several Soil Types shows AWHC estimates for some typical soil textures in the upper Midwest. Irrigation should be initiated for most crops before 50 percent of the available water is removed by the plants in the active root zone. In most vegetable crops, the majority of the roots are usually within the top 6 to 18

inches of soil. When using a trickle irrigation system on shallow-rooted, water sensitive crops (lettuce, peppers, etc.), the allowable depletion is generally 20 to 25 percent of AWHC and the system is run more frequently. With deeper rooted, more drought-tolerant crops (tomatoes, melons), a higher depletion allowance can be used without loss of yield or quality.

## Available Water Holding Capacities for Several Soil Types

Soil Texture	Available Water Holding Capacity	
	In Inches per Inch of Soil	In Inches per Foot of Soil
Loamy fine sand	0.08-0.12	0.96-1.44
Sandy loam	0.10-0.18	1.20-2.16
Loam	0.14-0.22	1.68-2.64
Silt loam	0.18-0.23	2.16-2.76
Clay loam	0.16-0.18	1.92-2.16

## Soil Water Monitoring

Two common ways of estimating soil water deficit to assist irrigation scheduling are:

1. Measuring soil water tension with soil moisture sensors.
2. Measuring the feel and appearance of soil with a soil probe.

Soil water tension can be monitored at a given point in the active root zone by electrical resistance moisture blocks or tensiometers. Soil tension or suction is a measurement usually expressed in centibars that describes how tightly water is held to the soil particles.

Tensiometers directly read soil tension between 0 and 80 centibars and work best in sandy loam or lighter textured soils. Resistance blocks work in a wider range of soil textures, and some types, such as Watermark sensors, work as well in lighter textured soils, as do tensiometers. If the soil texture is known, use the Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions table (below) to estimate the inches of soil water deficit for a given tension reading; use the Soil Tension Values for Different Soil Textures For Use in Scheduling Trickle Irrigation table (page 30) to estimate the point of 20 to 25 percent depletion.

For example, let's say you have a sandy loam soil that has an AWHC of 1.5 inches per foot. A tomato crop would be irrigated when 50 percent (or about 0.7 inch) has been depleted in the upper foot of soil, or when a 6-inch tensiometer reads 45 centibars (Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions). If we use the same soil for another example, a trickle-irrigated pepper crop would be irrigated when 20 to 25 percent (or 0.3 inch) has been depleted in the upper foot soil, or a 6-inch tensiometer reads 22 centibars (Soil Tension Values for Different Soil Textures For Use in Scheduling Trickle Irrigation).

To obtain representative soil tension readings with any sensor, the sensors should be left installed throughout the irrigation season and preferably at two or more locations in the field. Two depths are generally desired at each location. These depths should be about one-third and two-thirds of the active root zone, or about 6 and 12 inches.

Your local Extension office will have more information about in-field soil moisture monitoring tools.

## Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions

Soil Texture	Soil Tension in Centibars						
	10	30	50	70	100	200	1,500 <sup>1</sup>
Coarse sands	0	0.1	0.2	0.3	0.4	0.6	0.7
Fine sands	0	0.3	0.4	0.6	0.7	0.9	1.1
Loamy sands	0	0.4	0.5	0.8	0.9	1.1	1.4
Sandy loam	0	0.5	0.7	0.9	1.0	1.3	1.7
Loam	0	0.2	0.5	0.8	1.0	1.6	2.4

<sup>1</sup>1,500 cbs refers to the permanent wilting point and the soil deficit value is equal to the soil's total available water capacity.

## Soil Tension Values for Different Soil Textures For Use in Scheduling Trickle Irrigation

Soil Texture	0% Depletion of Available Water Holding Capacity (Field Capacity) <sup>1</sup>	20-25% Depletion of Available Water Holding Capacity <sup>2</sup>
	Soil Tension Values (in centibars)	
Sand, loamy sand	5-10	17-22
Sandy loam	10-20	22-27
Loam, silt loam	15-25	25-30
Clay loam, clay	20-40	35-45

<sup>1</sup> At field capacity the soil contains 100 percent of AWHC; any excess water in the rootzone has drained away.

<sup>2</sup> Start trickle irrigation for shallow-rooted crops at this point.

Information adapted from *New Jersey Commercial Vegetable Production Guide*, New Jersey Ag Expt. Station, Rutgers; and *Water Management in Drip-irrigated Vegetable Production* by T.K. Hartz, UC-Davis, Vegetable Research and Information Center.

## Frost Control

Irrigation can help protect vegetable crops, although it is not a common practice in the Midwest. With the proper equipment, growers must begin sprinkling as soon as the temperature reaches 34°F. Place a calibrated thermometer at the lowest elevation in the field at plant level, facing skyward. Continue sprinkling plants until the air temperature is greater than 30°F and the ice has melted from the plants.

To be effective, you need approximately 0.1 inch of water per hour, the sprinkling must be continuous, and the sprinklers should rotate at least once per minute. If conditions become windy and temperatures drop, it may be necessary to increase the amount of water to as much as 0.5 inch per hour. It is the process of the water freezing that gives off the heat to protect the crop. Therefore, liquid water must be present during the freezing period to protect the plants.

## Bees and Pollination

Pollination is the transfer of pollen from the male portions of the flower (stamens) to the female portions of the flower (pistils). This process is vital to the production of many vegetable crops, including cucumber, cantaloupe, pumpkin, squash, and watermelon. Some crops (such as tomato) are self-fertile, but wind or bees

must vibrate the flowers to release pollen for fertilization.

Honey bees are often thought of as the most prevalent pollinator for vegetable crops, but studies show that many species of native bees — including bumble bees and squash bees — play a vital role in pollinating many vegetable crops. Tomato, for example, benefit from the “buzz pollination” that bumble bees can provide. Honey bees are unable to buzz pollinate, and therefore do not play a role in tomato pollination. The squash bee, a North American native, is an important pollinator of pumpkins and other squash crops. Native bees are often active earlier in the day and at cooler temperatures than honey bees.

To ensure pollination, many vegetable growers rent honey bee hives rather than manage their own hives. Since honey bee colonies are occasionally in short supply, growers should communicate frequently with their bee providers.

In addition to renting honey bee hives, growers can improve the pollination services of native and non-native bees by increasing on-farm habitats. The Xerces Society for Invertebrate Conservation ([www.xerces.org](http://www.xerces.org)) and Pollinator Partnership ([www.pollinator.org](http://www.pollinator.org)) offer guides, plant lists, and other resources about building on-farm bee habitats.

At least 90 crops grown in the United States depend to some extent upon bees as pollinators, either for seed or fruit production. The exact number of honey bee hives needed to pollinate a crop depends on a number of factors, including the strength and condition of colonies, magnitude of the natural pollinator community, amount of wild flower material competing with the crop, attractiveness of the crop to bees, projected yield, and weather.

The following are guidelines for the number of hives to use when supplemental pollination is desired:

<b>cantaloupe</b>	(2 to 3 colonies per acre)
<b>cucumber</b>	(2 to 3 colonies per acre)
<b>pumpkin</b>	(1 colony per acre)
<b>squash</b>	(1 colony per acre)
<b>watermelon</b>	(1 to 5 colonies per acre — the pollination requirements of seedless varieties are generally greater than seeded)

The following vegetables will set fruit without bees, but bee activity has been shown to increase yields:

eggplant	okra
lima bean	pepper

Honey bees do not assist in the pollination of the following crops, but will collect pollen and/or nectar from them:

pea	sweet corn
snap bean	tomato

Do not place hives in a field until the crop's flowers are available to visit. If the hives are placed before the flowers are available, the bees will forage to surrounding areas and may not forage sufficiently in the crop that needs pollination. Bees forage best within about 100 yards of the colony. Therefore, if the field is large, the bees should be distributed in clusters around the field.

Bees also require a source of clean water. If not available nearby, set out a shallow container with fresh water.

## Bees and Pesticides

When foraging for pollen and nectar in flowering plants, honey bees, as well as bumble bees and native bees (solitary bees), may be exposed to a variety of different pesticides (insecticides and miticides) that can cause direct or indirect toxic effects. Direct toxicity occurs when honey bees are immediately killed after exposure to wet sprays or dried pesticide residues on leaves or flowers. Indirect toxicity is associated with sublethal effects on development, foraging behavior, immune system functionality, learning and memory retention, longevity, orientation, overwintering survival, and reproduction. In addition, indirect effects may be affiliated with social interactions as a result of honey bees sharing a contaminated food source.

In general, early morning or late evening applications of pesticides pose less of a hazard because this is when most bees are less active. However, this depends on temperature, as bumble bees are active at lower temperatures (40°F) whereas honey bees are active when temperatures are >50°F.

Do not apply pesticides to flowering plants or weeds. Systemic insecticides, applied as either drenches or granules, to the soil or growing medium, are less harmful to bees than foliar applications. The pesticide formulation can influence bee toxicity. For example, emulsifiable concentrates (EC) and water-soluble (WS) formulations are typically less harmful to bees than wettable powder (WP) formulations.

It is important to note that some fungicides can enhance the toxicity of certain insecticides to honey bees when mixed together. This enhanced toxicity is referred to as synergism, which means that the combined toxicity is greater than the sum of the toxicity of each pesticide applied separately. The ergosterol or sterol biosynthesis inhibiting (EBI) class of fungicides have been shown to increase the toxicity of certain insecticides in various chemical classes, including: organophosphates, pyrethroids, and neonicotinoids to honey bees. For instance, the toxicity of pyrethroid insecticides to honey bees is enhanced over a thousand fold when mixed with ergosterol biosynthesis inhibitors. In addition, mixing some neonicotinoid insecticides with certain fungicides can enhance toxicity to honey bees as much as a thousandfold.

In addition to fungicides, insect growth regulators, which are insecticides that disrupt insect growth and development, and eventually lead to death, are known to be harmful to honey bees. The three categories of insect growth regulators — chitin synthesis inhibitors, juvenile hormone mimics, and ecdysone receptor antagonists/agonists — have been reported to be directly and/or indirectly harmful to honey bees; especially the larvae (brood).

The Toxicity of Pesticides to Bees table (page 32) classifies pesticides (insecticides and miticides) based on their oral exposure to honey bees. It is important to read the pesticide label carefully to determine the potential level of toxicity to all bee types (honey bees, bumble bees, and native bees). Furthermore, you can incorporate into pollination contracts a list of pesticides, application methods, and timing of applications that are mutually agreeable to both growers/producers and beekeepers.

State laws may require that applicators notify beekeepers 24 hours before applying a pesticide that is directly or indirectly harmful to honey bees when [1] the treated crop is in flower (blooming) and [2] the field is greater than a half-acre and within a half-a-mile from a registered apiary. It is important to contact your state department of agriculture to determine if there are laws or regulations that protect other pollinators (bumble bees and native bees).

For more information on bees and pesticides, refer to the extension publication, **Pesticides and Bees** (Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3428. Kansas State University; Manhattan, KS. 8 pgs), which is available from this website: <https://www.bookstore.ksre.ksu.edu/pubs/MF3428.pdf>

## Toxicity of Pesticides to Bees<sup>1</sup>

Insecticides and miticides may vary in their toxicity to bees. Therefore, always determine the potential toxicity of insecticides or miticides to bees and apply them according to label directions. Apply these products in the early morning or late evening when bees are less active, which will minimize any direct or indirect exposure to spray residues.

Formulation may affect the toxicity of insecticides and miticides to bees. For example, the 50 WP (wettable powder) formulation of carbaryl (Sevin<sup>®</sup>) is more toxic to bees than the 4EC (emulsifiable concentrate) formulation.

This table the potential toxicity to bees of selected insecticides and miticides. This table is only a guide and should not replace carefully reading and following pesticide label instructions.

Very High Toxicity <sup>2</sup>	High Toxicity <sup>3</sup>	Moderate Toxicity <sup>4</sup>	Low Toxicity <sup>5</sup>
*Actara <sup>®</sup> (thiamethoxam)	Agri-Mek <sup>®</sup> (abamectin)	*Acramite <sup>®</sup> (bifenazate)	*Bleat <sup>®</sup> (flonicamid)
Agri-Mek <sup>®</sup> (abamectin), >21 fl. oz./A	Asana <sup>®</sup> (esfenvalerate), 4.8 fl. oz./A	Ammo <sup>®</sup> (cypermethrin), ≤1.28 fl. oz./A	Cryolite <sup>®</sup> (cryolite)
Ambush <sup>®</sup> (permethrin)	Brigade <sup>®</sup> (bifenthrin), 2.56 fl. oz./A	*Assail <sup>®</sup> (acetamiprid)	*Dimilin <sup>®</sup> (diflubenzuron)
Ammo <sup>®</sup> (cypermethrin), >1.28 fl. oz./A	Confirm <sup>®</sup> (tebufenozide) ≤21 fl. oz./A	*Avaunt <sup>®</sup> (indoxacarb)	DiPel <sup>®</sup> ( <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> )
Asana <sup>®</sup> (esfenvalerate), 7.3 fl. oz./A	Dibrom EC <sup>®</sup> (naled)	Azatin <sup>®</sup> (azadirachtin)	Diazinon G <sup>®</sup> (diazinon)
Baythroid <sup>®</sup> (cyfluthrin)	Di-Syston 8EC <sup>®</sup> (disulfoton), 16 fl. oz./A	Brigade <sup>®</sup> (bifenthrin), <2.56 fl. oz./A	Di-Syston G <sup>®</sup> (disulfoton)
Brigade <sup>®</sup> (bifenthrin), >23.8 fl. oz./A	Malathion EC <sup>®</sup> (malathion)	*Decis <sup>®</sup> (deltamethrin)	*Esteem <sup>®</sup> (pyriproxyfen)
Danitol <sup>®</sup> (fenpropathrin)	*Proaxis <sup>®</sup> (gamma-cyhalothrin), 2.56 fl. oz./A	Diatect <sup>®</sup> (diatomaceous earth)	Garlic Barrier <sup>®</sup>
Diazinon <sup>®</sup> (diazinon)	Sevin XLR PLUS <sup>®</sup> (carbaryl), <48 fl. oz./A	Di-Syston EC <sup>®</sup> (disulfoton), 8 fl. oz./A	Hot Pepper Wax <sup>®</sup> (capsaicin)
Dibrom <sup>®</sup> WP or D (naled)	Thimet EC <sup>®</sup> (phorate)	Fulfill <sup>®</sup> (pyrethroid)	*Intrepid <sup>®</sup> (methoxyfenozide)
Dimethoate <sup>®</sup> (dimethoate)	Vydate <sup>®</sup> (oxamyl), ≥64 fl. oz./A	Lannate <sup>®</sup> (methomyl)	Kryocide <sup>®</sup> (cryolite)
Imidan <sup>®</sup> (phosmet)	Warrior <sup>®</sup> (lambda-cyhalothrin), 2.56 fl. oz./A	Malathion ULV <sup>®</sup> (malathion), <3 fl. oz./A	Malathion G <sup>®</sup> (malathion)
Lorsban <sup>®</sup> (chlorpyrifos)		Metasystox-R <sup>®</sup> (oxydemeton methyl)	Metaldehyde <sup>®</sup> Bait (metaldehyde)
Malathion WP <sup>®</sup> (malathion)		Neemix <sup>®</sup> (azadirachtin)	Mocap G <sup>®</sup> (ethoprop)
Malathion ULV <sup>®</sup> (malathion), >8 fl. oz./A		Proclaim <sup>®</sup> (emamectin benzoate)	M-Pede <sup>®</sup> (soap)
Mustang Maxx <sup>®</sup> (zeta-cypermethrin)		Thimet G <sup>®</sup> (phorate)	Mycotrol <sup>®</sup> ( <i>Beauveria bassiana</i> )
Orthene <sup>®</sup> (acephate)		Vydate <sup>®</sup> (oxamyl), ≤32 fl. oz./A	Sevin G <sup>®</sup> (carbaryl)
Pounce <sup>®</sup> (permethrin)			sulfur (sulfur)
*Proaxis <sup>®</sup> (gamma-cyhalothrin), 3.84 fl. oz./A			*Surround <sup>®</sup> (kaolin)
Sevin 50WP <sup>®</sup> (carbaryl)			Vendex <sup>®</sup> (fenbutatin-oxide)
Sevin XLR-Plus <sup>®</sup> , (carbaryl) >48 fl. oz./A			
Warrior <sup>®</sup> (lambda-cyhalothrin), 3.84 fl. oz./A			

<sup>1</sup>Source: *How to Reduce Bee Poisoning from Pesticides*. Pacific Northwest Extension Publication PNW 518.

<sup>2</sup>Do not apply these to blooming crops or weeds at any time of day or night.

<sup>3</sup>Apply only during late evening (6 pm to midnight).

<sup>4</sup>Apply only during late evening, night or early morning (6 pm to 7 am).

<sup>5</sup>Can be applied at any time with reasonable safety to bees.

<sup>\*</sup>Products marked are relatively new and do not appear in the source cited, but information on their toxicity was taken from various Extension sources.

## Approximate Time from Pollination to Market Maturity Under Warm Growing Conditions

Vegetable	Days to Market Maturity
Bean	7-18
Cantaloupe	40-50
Corn, market	18-23 <sup>1</sup>
Corn, processing	21-27 <sup>1</sup>
Cucumber, pickling (3/4-1 1/8-inch diameter)	4-5
Cucumber, slicing	15-18
Eggplant (2/3 maximum size)	25-40
Okra	4-6
Pepper, green stage (about maximum size)	45-55
Pepper, red stage	60-70
Pumpkin, jack-o-lantern	60-90
Pumpkin, baking	65-75
Squash, summer, zucchini	3-4 <sup>2</sup>
Squash, winter, butternut	60-70
Squash, winter, hubbard	80-90
Squash, winter, acorn	55-60
Tomato, mature green stage	34-45
Tomato, red ripe stage	45-60
Watermelon	40-50

<sup>1</sup>From 50% silking.

<sup>2</sup>For a weight of 0.25-0.5 lbs.

## Precautions with Pesticides

Pesticides are designed to poison or otherwise manage pests. Many pesticide products may poison people, pets, livestock, wildlife, ornamental plants, and other non-target organisms. Pesticide applicators and their families are at increased risk of pesticide exposure. It is important to keep all pesticide exposures to an absolute minimum.

You must protect your family members, field workers, and other people from pesticide injuries. Most pesticide accidents result from careless practices or lack of knowledge about safe handling. The time you spend to learn about the safe use of pesticides is an investment in the health and safety of you, your family, and others.

The U.S. Environmental Protection Agency (EPA) places certain restrictions on the use of pesticide chemicals. These restrictions apply to chemicals applied to control insects, mites, plant diseases, weeds, nematodes, and

other pests. Such restrictions may prohibit the use of a chemical or allow residue tolerances on harvested vegetables. Growers must know what chemical to use on each vegetable; how to apply the products; the post-treatment re-entry interval, if any; when to use the chemicals with respect to farm worker and/or picker safety; and the environment and the harvest of each vegetable crop.

Growers must follow all label instructions regarding harvest restrictions to assure consumers that the food is free of dangerous residues and to comply with the law to prevent seizure of their crops. Here are some rules for the safe use of pesticides:

- Only mix the amount of a pesticide you can use in one day.
- If you do have leftover spray mix, the best way to dispose of it is by applying it to a labeled crop in a legal manner.
- Never dispose of surplus pesticides in a way that will result in the contamination of ground or surface waters.
- Rinse all empty containers three times before disposal.
- Pour the rinse water into the spray tank. Puncture or break triple-rinsed containers to facilitate drainage and to prevent reuse for any other purpose.
- Then dispose of the container according to label directions.

## Pesticide Signal Words

Each pesticide container is required by law to have signal words to quickly communicate information about the product's acute toxicity. The three signal words, as provided by the National Pesticide Information Center, are:

- CAUTION. This signal word means the pesticide is slightly toxic if eaten, absorbed through the skin, or inhaled, or it causes slight eye or skin irritation.
- WARNING. This signal word means the pesticide is moderately toxic if eaten, absorbed through the skin, or inhaled, or it causes moderate eye or skin irritation.
- DANGER. This signal word means the pesticide is highly toxic by at least one route of exposure. It may be corrosive, which would cause irreversible damage to the skin or eyes. It may be highly toxic if eaten, absorbed through the skin, or inhaled. If this is the case, then POISON must also be included in red letters on the front panel of the product label.

## Minimizing Pesticide Exposure

Signal words convey the acute toxicity of a pesticide. However, exposure to any pesticide, even those without signal words, can lead to long-term health effects. It's important to take precautions to minimize exposure to any and all pesticides. Check the product label for specific instructions to minimize exposure. Some label precautions include:

- Wear the proper respiratory equipment when handling or applying.
- Wear protective clothing that covers as much of the body as possible.
- Always use rubber gloves, not leather or cloth gloves, and never use bare hands to handle pesticides.
- Do not breathe in these pesticides when opening containers or mixing into spray tanks.
- Always wash hands, arms, and face immediately after handling, and before eating or smoking.
- Never smoke while handling or applying.
- Reduce all possible hazards of coming into direct contact with spray drift, and avoid spraying if conditions are too windy.
- Shower or bathe thoroughly after each day's work, and change clothes.
- Wash spray clothes separately from the family wash, then run another complete hot water and detergent wash cycle before washing other clothes.
- Wear clean overalls, underwear, socks, and cap each day you spray.
- Always keep pesticides in their original labeled containers, and store in a safe place.
- Store and dispose of containers according to information on pesticide labels.

### Worker Protection Standard

All pesticides with an "Agricultural Use Requirements" box on the label are subject to the regulations of the Worker Protection Standard (WPS). The WPS requires all employers to provide annual pesticide safety training to employees in a language that employees understand. Training must be approved by the Environmental Protection Agency. The Pesticide Educational Resources Collaborative (PERC) has a library of free EPA-approved training materials available in multiple languages on its website, including videos and flip charts.

## Restricted Pesticides

Most states have laws that restrict the use of certain pesticides and that describe where such pesticides can be obtained and used. Only individuals who are licensed by the state can apply restricted use pesticides.

Some restricted pesticides require applicators to notify occupants of land within 1,000 feet of the area to be treated at least 24 hours before application. Occupants also must be notified of any precautions they must take to ensure the safety of livestock and humans.

The U.S. EPA, state regulatory agencies, or pesticide companies can label specific pesticide formulations as "Restricted Use Only." To learn more about your state's laws about restricted use pesticides, contact your state department of agriculture or local extension office.

## Handling Pesticides

### Calibrating Application Equipment

Rate of application, granular and sprays, may vary with materials used. Equipment must be calibrated for each material applied to obtain accurate delivery. Here are suggested steps to calibrating selected applicators.

#### Boom-type Sprayers

High-pressure, high-volume sprayers have been used for row-crop pest control for many years. However, there is a growing trend to use sprayers that use lower volumes and pressures, and satisfactory pest control is possible at lower rates (if the sprayer is properly calibrated).

For effective applications, make sure to calibrate boom sprayers carefully. To calibrate a boom sprayer:

1. Clean sprayer, and replace all worn or defective parts; fill tank with water.
2. Adjust spray pressure and speed of tractor for nozzle size and output using manufacturer's directions.
3. Spray 1/4 acre (10,890 sq. ft.). Distance of travel will vary with boom width.

**For example, a 22-foot boom must travel 495 feet to cover 1/4 acre:**

$$\frac{1/4 \text{ acre (10,890 sq. ft.)}}{\text{Boom width (22 ft.)}} = \frac{\text{distance of travel}}{(495 \text{ ft.})}$$

4. Measure amount of water needed to refill the tank. This amount was applied to the 1/4 acre; thus, four times this amount is the gallonage per acre.

5. Adjustment in gallonage may be made either by varying tractor speed or by changing nozzle size. Recalibrate after making an adjustment.
6. Calculate acres covered by tank of spray solution, and add required amount of pesticide for total area sprayed.

It is of utmost importance that the spray unit functions properly. To obtain complete plant coverage and penetration, check the cleanliness of nozzles, nozzle wear, boom height, pressure gauge accuracy, agitation in tank, forward ground speed, mixing of materials, and nozzle spacing.

Also, due to lower pressures and volumes, paying attention to the wind becomes more important. Avoid using a boom-type sprayer in high winds. For more information, see *Boom Sprayer Calibration* (Ohio State University Extension FactSheet AEX-520-92), available from Ohioline, ohioline.osu.edu.

### **Band Sprayer**

1. Clean sprayer, and replace all worn or defective parts; fill tank with water.
2. Adjust spray pressure and speed of tractor for nozzle size and output using manufacturer's directions.
3. Spray 1/4 acre (10,890 sq. ft.). Distance traveled will vary with number of nozzles on the sprayer and width of the band sprayed by each nozzle.

**For example, spraying a 20-inch band over 4 rows using 1 nozzle per row requires 1630 ft. to cover 1/4 acre:**

$$\frac{1/4 \text{ acre (10,890 sq. ft.)}}{\text{Nozzles (4) x spray band width (1.67 ft.)}} = \frac{10,890 \text{ sq. ft.}}{6.68 \text{ ft.}} = \frac{\text{distance of travel}}{(1630 \text{ ft.})}$$

### **Measure amount of water needed to refill the tank.**

**This amount was applied to the 1/4 acre; thus, four times this amount is the gallonage per acre.**

4. Adjustment in gallonage may be made either by varying tractor speed or by changing nozzle size. Recalibrate after making an adjustment.
5. Calculate acres covered by tank of spray solution, and add required amount of pesticide for total actual area to be band treated.

### **Granular Band Applicator**

1. Set applicator dial or dials to give desired delivery rate of granules suggested for band treatment according to manufacturer's instructions.
2. Fill hoppers with granules to be used.
3. Travel across field at planting speed for the distance required to cover 1/16 acre (2,722 sq. ft.) per row. Collect granules for each row in a bag, bucket, or other container.

**For example: granular band application for a 40-inch row requires 817 ft. to cover 1/16 acre:**

$$\frac{1/16 \text{ acre (2,722 sq. ft.)}}{\text{Row width (3.33 ft.)}} = \frac{\text{distance of travel}}{(817 \text{ ft.})}$$

Weigh granules from each row separately, and multiply by 16 to find delivery per acre for each row.

4. Adjust each setting, and recalibrate until the desired delivery rate is obtained.

### **Airblast-type Sprayers**

Vegetable growers use airblast sprayers to control insects and diseases. However, pest control has been erratic. Airblast sprayer operation is more critical than a boom-type sprayer, so the operator must fully understand the machine and the job.

Do not operate an airblast sprayer under high-wind conditions. Preferably, that means wind speeds should be less than 5 mph unless it is necessary to apply the pesticide for timely control — even then, applicators must consider drift.

Do not overextend the coverage of the machine. Considerable visible mist from the machine moves into the atmosphere and does not deposit on the plant. If in doubt, use black plastic indicator sheets in the rows to determine deposit and coverage before a pest problem appears as evidence.

Use the correct gallonage and pressures to obtain proper droplet size to ensure uniform coverage across the effective swath width.

Adjust the vanes and nozzles on the sprayer unit to give best coverage. Vane adjustment must occur in the field, depending on terrain, wind, and crop.

Cross drives in the field allow the material to be blown down the rows instead of across them and help to give better coverage in some crops, such as tomatoes.

## Sprayer Delivery Rates

It is essential to apply pesticides at the specified rates for best control and protection and to not exceed residue tolerance. Check sprayers carefully several times a season for accurate delivery rates. Use new nozzle disks when needed. Use a speedometer operated from a nondriven wheel to determine the speed and delivery rate of the sprayer.

## Water Quality and Pesticide Applications

Water that is added to the pesticide spray tank may vary in pH, hardness and other qualities. These variations in water types may influence the effectiveness of the pesticide application. To learn about this subject, see *The Impact of Water Quality on Pesticide Performance* (Purdue Extension publication PPP-86) available from the Education Store, [www.edustore.purdue.edu](http://www.edustore.purdue.edu).

## Evaluating Compatibility of Pesticides Before Tank-mixing

1. Read the label and follow directions. If the label states, "Do not mix with other products," that direction must be followed.
2. Add products to the mix in this order:
  - a. Wettable powders.
  - b. Flowables.
  - c. Water-solubles.
  - d. Adjuvants.
  - e. Emulsifiable concentrates.
3. If using different products, and one label states, "Add last to spray tank," that direction must be followed.
4. If the label states, "Do not use adjuvants," that direction must be followed.
5. Add 1 pint of the carrier to a 1-quart jar. Use the same water or liquid fertilizer that will be used in the field.
6. Add 1 1/2 teaspoon of the wettable product(s) for each pound per acre to be used.
7. Next, add 1 teaspoon for each quart per acre of the liquid to be used.
8. These ratios will approximate 25 gallons per acre.
9. Shake the jar after adding each ingredient, and let it stand for a few minutes to see if there is a reaction. Keep adding each ingredient until all are added.
10. If there is a precipitate, or the material greases out, don't use it in the field.

11. The allowable separation in the jar depends on the amount of agitation in your equipment.
12. Good agitation is very important.
13. Storage conditions also are important.
  - a. Temperature: read the label for precautions.
  - b. Avoid contamination.
  - c. Do not leave material in the spray tank overnight or for more than several hours.
14. Normally, if there are problems, a compatibility agent will help.
15. This test only indicates physical compatibility; it does not indicate chemical reactions between products.

## Pesticide Formulations

The common types of pesticide formulations are:

- **Emulsifiable concentrates (EC):** the pesticide is dissolved and the emulsifying agent is added to an organic solvent.
- **Wettable powders (WP or W):** the pesticide is absorbed or adsorbed on powders that can be mixed with water because of an added wetting agent.
- **Dusts (D):** the pesticide is diluted with finely divided and ground materials.
- **Solutions:** the pesticide has a molecular mixture with the solvent.
- **Microencapsulated:** the pesticide is placed in pinhead-sized capsules that disintegrate slowly over a period of time.

Pesticides must be properly formulated and diluted to prevent injury to plants. Often, physical properties of certain pesticides make dilution difficult, leaving lasting residues that are hazardous to edible crops. New formulations enter the market each year.

## Storing Pesticides for Next Season

Growers who store pesticides always should consider safety and product quality, whether they will store products for a few weeks or a year or more. It is best not to have leftover pesticides. However, there usually are surplus pesticides at the end of the season because preseason purchases often are very economical.

Before storing pesticides always:

1. Read product labels. Certain formulations or products have special storage requirements, which are printed on the label.

2. Make certain the label is in good condition (legible) to know what is in the container and for directions for safe, effective, and legal use.
3. Write the purchase or delivery date on the label. Store the oldest materials near the front of the storage area and use older or opened products first. Products that are several years old may not be effective.
4. Keep an up-to-date inventory of pesticides to assist in purchase decisions and in emergencies.
  - a. Maintain storage temperatures between 32°F and 100°F. Ventilation is important for storage of most pesticides. Keep pesticides dry and out of direct sunlight.
5. Store herbicides away from other pesticides to prevent use mix-up, contamination, and possible plant damage. Never store pesticides with food or seed or near food or drinking water.
6. Permanently identify and lock pesticide storage areas.
7. Keep a supply of cat litter or other absorbent material in the storage to scatter over spills of liquid chemicals.
8. Hang a Class B inflammable liquids fire extinguisher nearby.

Here are some common pesticides with observations on their shelf-life under normal conditions:

### ***Insecticides***

- acetamiprid (Assail®): Several years.
- carbaryl (Sevin®) WP: Several years.
- carbaryl (Sevin®) F: Watch for settling.
- Diazinon EC®: 5-7 years if tightly sealed.
- Disulfoton (Di-Syston®): 2 years.
- Malathion WP®: Many years, but decomposes under high temperatures.
- Metasystox-R®: 2 years.
- Methoxychlor®: Many years.
- phosmet (Imidan®) WP: 2-3 years.

### ***Herbicides***

- glyphosate (Roundup®): 2 years, but do not allow to freeze.
- Casoron® (G): 2 years if cool and dry.
- Dacthal® (WP): 2 years.
- Kerb® (WP): 2 years.
- simazine (Princep®) (G, WP): Many years.
- Surflan® (G): 3 years, must be mixed well.
- Treflan® (G): 3 years if dry and under 80°F

### ***Empty Containers***

Most states have regulations that regulate the disposal of pesticide containers. The regulations often require that hazardous materials containers be disposed of in designated hazardous waste sites unless commercial applicators meet triple-rinsing and other requirements.

However, farmers and private applicators may be exempt from the regulations as long as they follow all label instructions when disposing of waste pesticides and containers.

## **Pesticide Application Record<sup>1</sup> and Written Notification for EPA Worker Protection Standards<sup>2</sup>**

<sup>1</sup>Information required by Federal and State Recordkeeping Requirements for Certified Applicators of Federally Restricted Use Pesticides (RUP). Records for restricted use pesticides must be maintained for two years from date of pesticide application.

<sup>2</sup>For EPA Worker Protection Standard, information in the shaded columns and safety data sheets must be recorded for all pesticides and Must be maintained at the centrally located posting area for two years after the restricted entry interval expires for all pesticides.

This form was prepared by a joint effort of the Northwest Horticulture Program, Department of Horticulture and Landscape Architecture, and Purdue Pesticide Programs, Purdue University.

## Organic Vegetable Production

Organic vegetable farming is a production system that relies on biological processes and natural materials to manage soil fertility and pest populations, and to promote healthy crop growth. With the federal Organic Foods Production Act, use of the term “organic” to describe an agricultural product in the marketplace is regulated. Vegetables sold as “organic” must be grown and handled according to the National Organic Rule and any applicable state regulations. The National Organic Rule prohibits the use of most synthetic chemicals (fertilizers, pesticides, etc.), and requires farmers to write and follow organic production plans, as well as keep farm and field records. Fields used to grow organic crops may not have had any prohibited material applied to them in the previous three years. In addition, USDA-accredited organic certification agents must inspect and certify all operations with more than \$5,000 in gross annual income from sales of products labeled “organic.”

Growers interested in transitioning to organic production should educate themselves about practices used in their area and plan carefully. Experience suggests that it can take a number of years for pest populations and soil nutrient cycles to adjust enough for successful organic production. Portions of this guide related to soil sampling, nutrient availability, and crop nutrient requirements include information relevant to organic production, as do the overviews of Insect Management Strategies, Disease Management Strategies, and Weed Management Strategies.

Growers should always check with their organic certification agents before using any product to make sure it meets their certifier’s criteria.

### Other organic production resources include:

*eXtension*, the national extension website, offers resources on organic agriculture at [www.extension.org](http://www.extension.org).

*Organic Vegetable Gardening Techniques* (University of Missouri Extension Guide G6220) provides an introduction to organic production techniques (available from University of Missouri Extension Publications, [extension.missouri.edu/publications](http://extension.missouri.edu/publications)).

*Resource Guide for Organic Insect and Disease Management* (Cornell University) provides specific recommendations for pests and diseases of major vegetable crops (available at [web.pppmb.cals.cornell.edu/resourceguide](http://web.pppmb.cals.cornell.edu/resourceguide)).

Appropriate Technology for Rural Areas (ATTRA) offers a number of publications on their website: [www.attra.org](http://www.attra.org).

The National Organic Program (NOP) offers a program handbook that provides a list of materials allowed for use in organic production, plus a complete list of accredited certification agents on their website: [www.ams.usda.gov/nop](http://www.ams.usda.gov/nop).

The Organic Materials Review Institute (OMRI) publishes a list of products they have found to meet certified organic production criteria. For details, visit [www.omri.org](http://www.omri.org).

The Sustainable Agriculture Research and Education (SARE) program offers a number of research-based publications about pest management, including organic options. A complete catalog is available at [www.sare.org/Learning-Center](http://www.sare.org/Learning-Center).

If you desire organic certification, you should contact a certification agent during the period of transition to organic production. The organizations on pages 40-41 have been accredited by the USDA as of September 2018. Contact them directly for information about fees and the certification procedure. The USDA lists all accredited organizations at [www.ams.usda.gov/services/organic-certification/certifying-agents](http://www.ams.usda.gov/services/organic-certification/certifying-agents).

Consult your local extension office for other resources available in your area.

## **Organic Certifiers Servicing the Midwest**

Some states do not have a National Organic Program certification agency headquartered in state. However, multiple certifying agencies service the Midwest region with traveling inspectors. Many take clients on a case-by-case basis, depending on the availability of inspectors and other factors. Here is a list of certifiers that are utilized in the Midwest, with notes on their service range.

### **California Certified Organic Farmers (CCOF)**

*Services entire United States, Canada, and Mexico.*

2155 Delaware Avenue, Suite 150

Santa Cruz, CA 95060

831-423-2263

Fax: 831-423-4528

Email: [ccof@ccof.org](mailto:ccof@ccof.org)

[www.ccof.org](http://www.ccof.org)

### **Ecocert ICO**

*Services entire United States and Canada.*

P.O. Box 158

Plainfield, IN 46168

888-337-8246 (toll free)

Fax: 317-708-0628

Email: [info.ecocertico@ecocert.com](mailto:info.ecocertico@ecocert.com)

[www.ecocertico.com](http://www.ecocertico.com)

### **Global Organic Alliance**

*Services entire United States.*

P.O. Box 530

3185 Township Road 179

Bellefontaine, OH 43311

937-593-1232

Fax: 937-593-9507

Email: [goaorg@centurylink.net](mailto:goaorg@centurylink.net)

[www.goa-online.org](http://www.goa-online.org)

### **International Certification Services (ICS)**

*Services worldwide.*

PO Box 517

301 5th Avenue SE

Medina, ND 58467

701-486-3578

Fax: 701-486-3580

Email: [info@ics-intl.com](mailto:info@ics-intl.com)

[www.ics-intl.com](http://www.ics-intl.com)

### **Iowa Department of Agriculture and Land Stewardship**

*Services Iowa only.*

Organic Certification Program

Maury Wills

502 East 9th Street

Des Moines, IA 50319

515-281-5783

Email: [OrganicProgram@iowaagriculture.gov](mailto:OrganicProgram@iowaagriculture.gov)

[www.iowaagriculture.gov/AgDiversification/organicCertification.asp](http://www.iowaagriculture.gov/AgDiversification/organicCertification.asp)

### **MOSA Certified Organic**

*Services producers and processor/handlers throughout the United States with current clients in California, Florida, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New York, North Carolina, North Dakota, Ohio, Pennsylvania, South Dakota, Tennessee, Utah, and Wisconsin.*

P.O. Box 821

122 West Jefferson Street

Viroqua, WI 54665

608-637-2526

Fax: 608-637-7032

Email: [mosa@mosaorganic.org](mailto:mosa@mosaorganic.org)

[www.mosaorganic.org](http://www.mosaorganic.org)

### **Minnesota Crop Improvement Association**

*Services Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin.*

1900 Hendon Avenue

St. Paul, MN 55108

612-626-6305

855-213-4461 (toll free)

Fax: 612-625-3748

Email: [mncia@mncia.org](mailto:mncia@mncia.org)

[www.mncia.org](http://www.mncia.org)

### **Nature's International Certification Services (NICS)**

*Services Alabama, Arkansas, Colorado, Florida, Idaho, Illinois, Indiana, Iowa, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Mexico, New York, North Carolina, North Dakota, Ohio, Pennsylvania, South Dakota, Texas, and Wisconsin.*

224 East State Highway 56

Viroqua, WI 54665

608-637-7080

Fax: 608-637-7460

Email: [nics@naturesinternational.com](mailto:nics@naturesinternational.com)

[www.naturesinternational.com](http://www.naturesinternational.com)

**Oregon Tilth Certified Organic**  
*Services entire United States, Canada, and Mexico.*  
 2525 SE 3rd Street  
 Corvallis, OR 97333  
 503-378-0690  
 877-378-0690 (toll free)  
 Fax: 541-753-4924  
 Email: [organic@tilth.org](mailto:organic@tilth.org)  
[www.tilth.org](http://www.tilth.org)

**Organic Crop Improvement Association (OCIA) International**  
*Services entire United States with additional regional offices in Canada, Mexico and Japan.*  
 1340 North Cotner Boulevard  
 Lincoln, NE 68505  
 402-477-2323  
 Fax: 402-477-4325  
 Email: [info@ocia.org](mailto:info@ocia.org)  
[www.ocia.org](http://www.ocia.org)

**Ohio Ecological Food and Farm Association**  
*Services Illinois, Indiana, Iowa, Kentucky, Michigan, Missouri, New York, Ohio, Pennsylvania, West Virginia, Wisconsin, and Virginia.*  
 41 Croswell Road  
 Columbus, OH 43214  
 614-262-2022  
 Fax: 614-421-2011  
 Email: [organic@oeffa.org](mailto:organic@oeffa.org)  
[www.oeffa.org](http://www.oeffa.org)

**Pro-Cert Organic Systems Ltd.**  
*Services entire United States and Canada.*  
 2311 Elm Tree Road  
 Cambray, ON K0M 1E0  
 705-374-5602  
 Fax: 705-374-5604  
 Email: [infoebo@pro-cert.org](mailto:infoebo@pro-cert.org)  
[www.pro-cert.org](http://www.pro-cert.org)

**Quality Assurance International**  
*Services entire United States and Canada.*  
 4370 La Jolla Village Drive, Suite 300  
 San Diego, CA 92122  
 858-200-9704  
 Email: [info@qai-inc.com](mailto:info@qai-inc.com)  
[www.qai-inc.com](http://www.qai-inc.com)

## ***Yield of Vegetable Crops***

Crop	Expected Yields in Tons per Acre		
	Average	Good	Excellent
Asparagus	1	1.5	2
Bean, snap	2	3	4
Cabbage	13	15	20
Cantaloupe	10	15	19
Cucumber (slicing)	9	12	15
Cucumber (pickling, hand harvest)	6	10	12
Onion	13	18	23
Pepper, green	14	17	20
Potato (fall)	10	15	20
Pumpkin	10	15	25
Spinach	6	8	10
Summer squash	10	13	16
Sweet corn	4.5	8	10
Sweet potato	7	12	15
Tomato (fresh market)	11	13	15
Tomato (processing)	25	29	33
Watermelon	15	20	25

This table only provides general yield estimates for new or prospective growers. The USDA-National Agricultural Statistics Service Vegetable Survey provides more accurate information.

# Postharvest Handling and Storage Life of Fresh Vegetables

A lack of adequate refrigeration and cooling will shorten the shelf-life and lower the quality of fresh vegetables. Cucumber, eggplant, lettuce, green or ripe pepper, potato, snap bean, summer squash, and tomato are among the most susceptible vegetables to chilling or freezing injury. Some cold injury symptoms that can make vegetables unmarketable. The most typical include pitting, water-soaked spots, browning, surface decay, and, in pepper and tomato, failure to ripen.

The following list of recommended storage condition information is adapted from *The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks* (USDA-ARS Agriculture Handbook Number 66, [www.ba.ars.usda.gov/hb66/contents.html](http://www.ba.ars.usda.gov/hb66/contents.html)), *Knott's Handbook for Vegetable Growers* (Donald N. Maynard and George J. Hochmuth, 5th ed., 2007), and "Properties and Recommended Conditions for Long-Term Storage of Fresh Fruits and Vegetables" (Marita Cantwell, University of California-Davis, Postharvest Technology webpage, [postharvest.ucdavis.edu](http://postharvest.ucdavis.edu)).

Vegetable	Storage Conditions		
	Temperature (°F)	Relative Humidity (%)	Relative Storage Life
Asparagus	36	95-100	2-3 weeks
Beans, snap	40-45	95	7-10 days
Beets & carrots, bunched	32	98-100	10-14 days
Broccoli	32	95-100	10-14 days
Cabbage, late	32	98-100	5-6 months
Cantaloupe	36-41	95	2-3 weeks
Cauliflower	32	95-98	3-4 weeks
Cucumber	50-54	85-90	10-14 days
Eggplant	50-54	90-95	1-2 weeks
Greens — collards, kale, & spinach	32	95-100	10-14 days
Lettuce	32	98-100	2-3 weeks
Okra	45-50	90-95	7-10 days
Onions, dry	32	65-70	1-8 months
Onions, green	32	95-100	3 weeks
Peas, in pods	32	90-98	1-2 weeks
Peas, southern	40-41	95	6-8 days
Pepper, green	45-55	90-95	2-3 weeks
Pepper, ripe	42-45	90-95	1 week
Potato, early	a	90-95	a
Potato, late	b	90-95	b

Vegetable	Storage Conditions		
	Temperature (°F)	Relative Humidity (%)	Relative Storage Life
Pumpkin	54-59	50-70	2-3 months
Radish	32	95-100	1-2 months
Rhubarb	32	95-100	2-4 weeks
Squash, summer	40-45	95	1-2 weeks
Squash, winter	54-59	50-70	c
Sweet corn	32	95-98	2-5 days, up to 21 days for supersweet cultivars
Sweet potato	55-59	85-95	4-7 months
Tomato, light red	50-55	90-95	1 week
Tomato, mature-green	50-60	90-95	1-2 weeks
Tomato, firm-ripe	46-50	85-90	3-5 weeks
Turnip root	32	95	4-5 months
Watermelon	50-60	90	2-3 weeks

<sup>a</sup>Most summer-harvested potatoes are not stored. However, they can be held 4-5 months at 40°F if cured 4-5 days at 60-70°F before storage. They can be stored 2-3 months at 50°F without curing. Potatoes for chips should be held at 70°F or conditioned for best chip quality.

<sup>b</sup>Fall-harvested potatoes should be cured at 50-60°F and high relative humidity for 10-14 days. Storage temperatures for seed or table stock should be lowered gradually to 38-40°F. Potatoes intended for processing should be stored at 50-55°F. Those stored at lower temperatures or with a high reducing sugar content should be conditioned at 70°F for 1-4 weeks or until trial cooking tests are satisfactory.

<sup>c</sup>Winter-squash varieties differ in storage life. Acorn squash can be stored for 35-55 days, butternut squash for 60-90 days, and Hubbard squash for 180 days.

## Conversions for Liquid Pesticides on Small Areas

Rate per Acre	Rate per 1,000 Square Feet	Rate per 100 Square Feet
1 pint	0.75 tablespoon	0.25 teaspoon
1 quart	1.5 tablespoons	0.5 teaspoon
2 quarts	3 tablespoons	1 teaspoon
1 gallon	6 tablespoons	2 teaspoons
25 gallons	4.5 pints	1 cup
50 gallons	4.5 quarts	1 pint
75 gallons	7 quarts	1.5 pints
100 gallons	9 quarts	1 quart

Check the pesticide label for the particular crop, pest, and site of your planned use.

## Germination and Growing Guide for Vegetable Plants and Herbs

Crop	No. of Seeds per Oz	Opt. Germination Temp. (°F)	Usual Day Temp. (°F)	Min. Night Temp. (°F)	Time for Uniform Germination (days)
Asparagus	700	75			10-21
Broccoli	9,000	68-86	65-70	60	5-10
Brussels sprouts	9,000	68-86			5-10
Cabbage	9,000	85	65	60	5-10
Chinese cabbage	18,000	85			3-7
Cauliflower	9,000	80	65-70	60	5-10
Celery	72,000	70	65-70	60	10-21
Collards	9,000	68-86			3-10
Cucumber	1,100	68-86	70-75	65	3-7
Dandelion (for greens)	35,000	68-86			7-21
Eggplant	6,500	85	70-85	65	7-14
Endive	27,000	68-86	70-75	70	5-14
Kale	9,000	68-86			3-10
Leek	11,000	68			6-14
Lettuce	25,000	75	60-65	40	7
Okra	500	68-86			5-14
Pak-choi	18,000	68-86			3-7
Parsley	18,500	75			11-28
Pepper	4,500	85	70-75	60	6-14
Sweet potato plants (from tuberous roots bedded in sand)		77	75-85		14-21
Squash	400	80-90	70-75	65	4-7
Tomato	11,500	85	65-75	60	5-14
<b>Herbs</b>					
Anise	9,600	70			5
Basil, dark opal	20,000	70			10
Basil, leaves	9,600	70			10
Borage	2,100	70			8
Chives	22,000	60			10
Coriander	1,240	70			10
Dill	6,300	60			10
Fennel, sweet	4,000	65			10
Marjoram, sweet	100,000	70			8
Rosemary	30,000	60			15
Sage	3,250	70			15
Thyme	96,000	75			10

## Using a Plant Diagnostic Lab

The best way to identify insects, plants and plant diseases, or diagnose plant and pest problems, is to send a sample to a diagnostic laboratory. The National Plant Diagnostic Network website ([www.npdn.org](http://www.npdn.org)) lists diagnostic laboratories by state and region. Contact individual laboratories for specific submission and fee information (see page 45-46).

To ensure an accurate diagnosis, it's important to collect and ship your specimens properly. Here are a few guidelines for collecting and shipping specimens to a diagnostic lab.

1. Collect fresh specimens. Send a generous amount of material, if available.
2. Ship specimens in a crush-proof container immediately after collecting. If holdover periods are encountered, keep specimen cool. Mail packages to avoid weekend transit.
3. Incomplete information or poorly selected specimens may result in an inaccurate diagnosis or inappropriate control recommendations. Badly damaged specimens are often unidentifiable and additional sample requests can cause delays.

## Submitting Plant Specimens for Disease/Injury Diagnosis

**Herbaceous Plants.** For generally declining, wilting, or dying plants, send several whole plants showing a range of symptoms (early through more advanced) with roots and adjacent soil intact. Dig up the plants carefully. Place roots and surrounding soil in a plastic bag and fasten it to the base of stem with a twist tie or string. Do *not* add water or moist paper towels. Soil and attached roots of smaller specimens may also be secured in a double layer of heavy-duty aluminum foil pressed around the root system. Wrap the plants in dry newspaper and place in a crush-proof container for shipment.

**Leaves/fruit/tubers.** When localized infections (such as leaf spots or fruit rots) are suspected, send specimens representing early and moderate stages of disease. Press leaves flat between dry paper towels, newspaper, or cardboard. Wrap fruits or tubers in dry newspaper. Place in a crush-proof container for shipment.

## Submitting Insect Specimens

Package insects carefully so they aren't damaged when they arrive at the lab. Separate and label the specimens if you send more than one type in the same package. Provide the appropriate information for each specimen.

**Tiny or Soft-bodied Specimens.** Submit such specimens (aphids, mites, thrips, caterpillars, grubs, spiders) in a small, leak-proof bottle or vial of 70 percent alcohol or hand sanitizer. Rubbing alcohol (isopropyl) is suitable and readily available. Do not submit insects in water, formaldehyde, or without alcohol or they will ferment and decompose. Package carefully to assure vials do not break in shipment. Small insects found on leaves can also be submitted on the plant material. Wrap several leaves in dry newspaper, and then seal in a plastic bag to prevent insects from escaping.

**Hard-bodied Specimens.** Submit such specimens (flies, grasshoppers, cockroaches, wasps, butterflies, beetles) dry in a crush-proof container. *Do not* tape insects to paper or place them loose in envelopes.

## Submitting Samples for Nematode Analysis

If you suspect a nematode problem, contact clinics for state-specific submission information (see below).

In general nematode identification requires collection of at least one quart of soil from the root zone of affected plants. Include roots if the plants are actively growing.

Place the entire sample in a plastic bag. *Do not* add water or allow it to dry out. Protect the sample from extreme heat (for example, don't leave samples inside a parked vehicle in direct sunlight). It is often helpful to collect a second, similar sample from a nearby area where plant growth appears normal.

Attach a label, note, or tag identifying the sample to the outside of each bag or package.

Selected university diagnostic laboratories and other laboratory services are provided below.

## Selected University Laboratory Services

### Illinois

University of Illinois Plant Clinic  
 S-417 Turner Hall  
 1102 S. Goodwin Avenue  
 University of Illinois Urbana, Illinois 61801  
 217-333-0519  
[web.extension.illinois.edu/plantclinic](http://web.extension.illinois.edu/plantclinic)  
[www.facebook.com/UofIPlantClinic](http://www.facebook.com/UofIPlantClinic)

Contact:  
[plantclinic@illinois.edu](mailto:plantclinic@illinois.edu)  
 217-333-2478

### Indiana

Plant and Pest Diagnostic Laboratory  
 Purdue University  
 LSPS 101  
 915 W. State Street  
 West Lafayette, IN 47907-2054  
 765-494-7071  
 Fax: 765-494-3958  
[ppdl.purdue.edu](http://ppdl.purdue.edu)

Contacts:  
 Tom Creswell  
[creswell@purdue.edu](mailto:creswell@purdue.edu)  
 John Bonkowski  
[jbonkows@purdue.edu](mailto:jbonkows@purdue.edu)

Water Quality (microbiology)  
 Indiana State Department of Health Laboratories  
 550 W 16th Street, Suite B  
 Indianapolis, IN 46202  
 317-921-5500

ISDH lists private laboratories certified for drinking water microbiology at [www.in.gov/isdh/22450.htm](http://www.in.gov/isdh/22450.htm)

Purdue Agronomy Extension lists labs that participate in proficiency testing programs for soil, plant tissue, and manure testing at [https://ag.purdue.edu/agry/soilfertility/pages/soil\\_testing.aspx](https://ag.purdue.edu/agry/soilfertility/pages/soil_testing.aspx)

### Iowa

Iowa State University Plant and Insect Diagnostic Clinic  
 Iowa State University  
 Ames, Iowa  
 (515) 294-0581  
 Fax: 515-294-9420

<https://hortnews.extension.iastate.edu/pidc>  
 Clinic Services and Information:  
[www.ipm.iastate.edu/ipm/info/contact](http://www.ipm.iastate.edu/ipm/info/contact)

Contact:  
 Laura Jesse Iles and Lina Rodriguez Salamanca  
[pidc@iastate.edu](mailto:pidc@iastate.edu)

Soil and Plant Analysis Laboratory  
 G501 Agronomy Hall  
 Iowa State University  
 Ames, Iowa 50011-1010  
 515-294-3076  
 Fax: 515-294-5567  
[soiltest@iastate.edu](mailto:soiltest@iastate.edu)

The Iowa Department of Agriculture and Land Stewardship lists private certified soil testing laboratories at [www.iowaagriculture.gov/feedAndFertilizer/pdfs/2015/Cert-LabsafterQ42015.pdf](http://www.iowaagriculture.gov/feedAndFertilizer/pdfs/2015/Cert-LabsafterQ42015.pdf)

Water Quality (microbiology)  
 State Hygienic Laboratory Client Services  
 2490 Crosspark Road  
 Coralville, IA 52241-4721  
 319-335-4500 or 800-421-4692

Iowa State University Food Science and Human Nutrition lists private water quality laboratories at [www.fshn.hs.iastate.edu/wp-content/uploads/2012/05/Iowa-Water-Testing-Labs.pdf](http://www.fshn.hs.iastate.edu/wp-content/uploads/2012/05/Iowa-Water-Testing-Labs.pdf)

## Kansas

Plant Disease Diagnostic Lab Pathology  
1712 Claflin Road  
4032 Throckmorton Hall  
Kansas State University  
Manhattan, KS 66506-5504  
785-532-5810  
Fax: 785-532-5692  
[www.plantpath.k-state.edu/extension/diagnostic-lab](http://www.plantpath.k-state.edu/extension/diagnostic-lab)  
Contact:  
Judith O'Mara  
jomara@ksu.edu

## Michigan

Michigan State University Diagnostic Services  
578 Wilson Road., Room. 107  
East Lansing, MI 48824-6469  
517-355-4536  
Fax: 517-432-0899  
[www.pestid.msu.edu](http://www.pestid.msu.edu)  
Contact for general questions:  
517-432-0988  
[pestid@msu.edu](mailto:pestid@msu.edu)  
MSU Soil and Plant Nutrient Laboratory  
Department of Plant, Soil and Microbial Sciences  
Plant and Soil Sciences Building  
1066 Bogue Street, Room A81  
East Lansing, Michigan 48824-1325  
517-355-0218  
[www.spnl.msu.edu](http://www.spnl.msu.edu)  
Contact:  
Jon Dahl  
[dahl@msu.edu](mailto:dahl@msu.edu)

## Minnesota

Plant Disease Clinic  
Department of Plant Pathology  
495 Borlaug Hall  
991 Upper Buford Circle  
University of Minnesota  
St. Paul, MN 55108  
612-625-1275  
Fax: 612-625-9728  
[pdc.umn.edu](mailto:pdc.umn.edu)  
Contact:  
Brett Arenz  
[aren0058@umn.edu](mailto:aren0058@umn.edu)

## Soil Testing Laboratory

College of Food, Agricultural and Natural Resource Sciences  
Room 135, Crops Research Building  
1902 Dudley Ave.  
St. Paul, MN 55108-6089  
612-625-3101  
Fax: 612-624-3420

### Contact:

Brian Barber  
[bbarber@umn.edu](mailto:bbarber@umn.edu)

## Missouri

Plant Diagnostic Clinic  
28 Mumford Hall  
Columbia, MO 65211  
573-882-3019  
[plantclinic.missouri.edu](http://plantclinic.missouri.edu)  
SCN Diagnostics (nematology lab)  
1721 E. Campus Drive  
University of Missouri Columbia, MO 65201  
573-884-9118

[SCNdiagnostics@missouri.edu](mailto:SCNdiagnostics@missouri.edu)

### Contact:

Amanda Howland  
[SCNdiagnostics@missouri.edu](mailto:SCNdiagnostics@missouri.edu)

MU Soil and Plant Testing Lab  
23 Mumford Hall  
Columbia, MO 65211  
573-882-3250

[soiltestingservices@missouri.edu](mailto:soiltestingservices@missouri.edu)

MU Delta Soil Testing Lab  
PO Box 160  
Portageville, MO 63873  
573-379-5431

## Ohio

C. Wayne Ellett Plant and Pest Diagnostic Clinic  
Ohio State University  
8995 E. Main St., Bldg. 23  
Reynoldsburg, OH 43068  
614-292-5006  
Fax: 614-466-9754  
[ppdc@osu.edu](mailto:ppdc@osu.edu)

# Farm Labor Law Information

For information about the Immigration and Reform Act and current related farm and labor laws that specify employer responsibilities and seasonal agricultural worker status, contact the resources below.

## Federal

Office of Special Counsel, Washington, D.C.  
 Employer Information: 800-255-8155  
 U.S. Citizenship and Immigration Services 800-375-5283  
 800-767-1833 (TTY)  
[www.uscis.gov](http://www.uscis.gov)

## Illinois

Travel Control Section, Immigration and Naturalization Service  
 10 W. Jackson  
 Chicago, IL 60604  
 (Migrant Farm Workers and Farm Labor)  
 Department of Labor  
 310 S. Michigan Ave.  
 Chicago, IL 60604  
 312-793-2804

## Indiana

Immigration and Naturalization Service (INS)  
 950 N. Meridian Street, Room 400  
 Indianapolis, IN 46204-3915

Indiana Department of Workforce Development  
 Indiana Government Center South  
 10 North Senate Avenue Indianapolis, IN 46204  
 1-888-WORKONE

[workone@dwd.in.gov](mailto:workone@dwd.in.gov) [www.IN.gov/dwd](http://www.IN.gov/dwd)

Migrant Farmworkers Project  
 Krin Flaherty  
 105 E. Jefferson Blvd., Suite 600  
 South Bend, IN 46601  
 800-288-8121 (toll free)  
 574-234-8121

## Iowa

Iowa Department of Workforce Development  
 Attn: John McDonald, Monitor Advocate  
 150 Des Moines St.  
 Des Moines, IA 50309  
 515-281-9336

## Kansas

Kansas Department of Commerce Workforce Compliance and Oversight, Legal  
 Kansas Department of Commerce  
 1000 SW Jackson St., STE 100  
 785-296-5014  
[www.kansascommerce.com](http://www.kansascommerce.com)

## Michigan

Michigan Workforce Development Agency Victor Office Center  
 201 N. Washington Square  
 Lansing, MI 48913  
 517-335-5858  
 Fax: 517-241-8217  
 TTY: 888-605-6722

Michigan Department of Licensing and Regulatory Affairs (LARA)  
 (Employment Relations, MIOSHA, Workers Comp, and more)  
 PO Box 30004  
 Lansing, MI 48909  
 517-373-1820

## Minnesota

Immigration and Naturalization Service (INS)  
 2910 Metro Dr.  
 Bloomington MN 55425

Minnesota Labor and Industry Department  
 443 Lafayette Road  
 St. Paul, MN 55155 800-375-5283

## Missouri

Missouri Department of Economic Development, Division of Workforce Development  
 421 E. Dunklin St.  
 Jefferson City, MO 65101  
 573-751-3773  
 573-751-9571

## Ohio

Peggy Kirk Hall  
 25C Agricultural Admin. Bldg.  
 2120 Fyffe Road  
 Columbus, OH 43210  
 614-247-7898

# Produce Food Safety

Produce food safety aims to reduce the risk of produce contamination by human pathogens or other contaminants during field production and postharvest handling. Good Agricultural Practices (GAPs) are guidelines and practices that can prevent or reduce the risk of produce contamination by a foodborne pathogen, or other contaminant, in the field and during postharvest handling. To reduce the risk of contamination by a foodborne pathogen, vegetable growers should adopt GAPs, paying particular attention to water management, waste (manure), worker sanitation/hygiene, and wildlife. Purdue Extension Publication GP-1-W ([https://mdc.itap.purdue.edu/item.asp?Item\\_Number=GP-1-W](https://mdc.itap.purdue.edu/item.asp?Item_Number=GP-1-W)) introduces produce food safety.

## Water Management

Water can be a major source of contamination in crop production. It is important to make sure water that comes in contact with the crop is of adequate quality for its intended use. Growers should monitor the quality (presence of bacteria) of irrigation and process (postharvest) water through testing.

Water should be tested for generic *E. coli* at least annually, or as required by law or individual food safety programs. Current guidelines allow no more than 126 colony forming units of generic *E. coli* per 100 milliliters (CFU/100 ml) of water intended for pre-harvest uses. Water exceeding these parameters may require a corrective action, such as water treatment, inspection and repair of the water system, or extending the time between the last irrigation and harvest. *E. coli* should be below detectable limits (typically reported as  $\leq 0$  CFU/ml) for postharvest uses (product cleaning, product cooling, etc.). Information on how to find water quality laboratories is in the Laboratory Services section of this guide on pages 45-46.

## Irrigation Water

Pathogens can be introduced into irrigation water through manure runoff from animal production facilities, sewage runoff from treatment facilities or septic systems, or directly from wildlife. Extreme rainfall, manure spills, or human waste can increase the probability of contamination occurring.

Groundwater is the least likely water source to be contaminated. Well water, when used directly, bears a relatively low contamination risk, provided the wells are properly constructed and maintained. Wellheads should be protected from contamination by elevating the wellhead above ground level and using backflow prevention devices. Surface water (such as ponds, creeks, and rivers) carries the highest risk for contamination. Microbe levels in surface water may change rapidly. Also, surface water cannot be protected from contamination by wildlife, runoff, or

other potential sources of contamination. The following measures may reduce the risk of microbial contamination in surface water:

1. Construct ponds well away from apparent sources of contamination such as livestock facilities and pastures, composting pads, and sewage systems.
2. Fence ponds to prevent wildlife and domestic animals from entering and contaminating the water and surroundings.
3. Redirect runoff to flow away from the pond by building a bank or channel.
4. Establish vegetation buffer zones around ponds to filter runoff before it gets into the pond.
5. If irrigating from a creek or river, consider using a settling pond. This allows large particles that may contain bacteria to settle at the bottom.
6. Communicate with neighboring livestock producers and work collaboratively to maximize the distance between livestock and water used for irrigation, spraying, or other crop production practices.
7. Heavy rain may wash in sediment and high microbial contamination loads. Use caution irrigating after heavy rain.

Water application methods (drip, overhead, or furrow irrigation), timing (how close to harvest), and vegetable types (above, below, or on the soil) are also factors to consider. These factors are often interrelated and have to be considered in combination.

## Process Water

Water is used in many processing (or postharvest) operations, including washing, cooling, top-icing, and transferring product with flumes. Contaminated process water has the potential to introduce and spread contamination throughout an entire harvest lot. Process water that is not of adequate microbial quality can easily transfer pathogens from contaminated to noncontaminated produce.

To prevent cross-contamination, sanitizers may be added to process waters. There are a number of chemical and nonchemical (called pesticide devices by FDA) sanitizers, such as chlorine, chlorine dioxide, peracetic acid, hydrogen peroxide, ozone, and UV light. The treatment chosen depends on various factors, such as the type of produce, type of postharvest operation, market requirements, etc. Seek sound technical advice before investing in a sanitizing system. Any chemical treatment used should be labeled for its intended use. See page 49 for a list of EPA-registered products for use in produce wash water. Growers who use sanitizers should be prepared to monitor water pH, turbidity, temperature, and other factors that affect sanitizer performance.

## Sanitizers Approved for Wash or Process Water

The U.S. EPA has labeled these sanitizing agents for use in wash or process water for vegetables. Individuals must check with their respective states to determine if a state label is available.

Product Name	Active Ingredient	Company	EPA Reg. No.
Agclor®	sodium hypochlorite	Decco	2792-62
Anthium Dioxide®	chlorine dioxide	International Dioxide	9150-2
Antimicrobial Fruit and Vegetable Treatment®	lactic acid	Ecolab	1677-234
Biosafe Disease Control RTU®	hydrogen peroxide	Biosafe Systems	70299-9
Biosafe Fruit & Vegetable Wash®	hydrogen peroxide	Biosafe Systems	70299-9
BioSide HS-15%®	peroxyacetic acid	Enviro Tech	63838-2
Biotrol 150®	peroxyacetic acid	U.S. Water Services	63838-2-71675
Bromide Plus®	sodium bromide	Clearon	8622-49-69470
Bulab 6040®	sodium bromide	Buckman Laboratories	1448-345
Busan 1167®	sodium bromide	Buckman Laboratories	1448-345
Carnebon 200®	chlorine dioxide	International Dioxide	9150-3
Chlor San 1050®	sodium hypochlorite	Chemstation Of Northern Indiana	67649-20001-74373
Chlor-Clean 12.5®	sodium hypochlorite	Madison Chemical	550-198-110
Chlorine Liquefied Gas Under Pressure®	chlorine	Olin Chlor Alkali Products	72315-1
Clearitas 450®	sodium hypochlorite	Blue Earth Labs	87437-1
DicaSan PAA®	peroxyacetic acid	Dubois Chemicals	63838-1-3635
Enviroguard Sanitizer®	peroxyacetic acid	Rochester Midland	63838-1-527
Formula 308®	sodium hypochlorite	Garratt Callahan	33981-20002-8540
Hydroxysan PA No. 480®	peroxyacetic acid	Hydrite Chemical	63838-1-2686
Induchlor 70®	calcium hypochlorite	PPG Industries	748-296
K-Brom 40®	sodium bromide	Water Science Technologies	88714-3
KC-610®	peroxyacetic acid	Packers Chemical	63838-1-63679
Madison Oxy-San Acid Sanitizer Disinfectant®	peroxyacetic acid	Madison Chemical	63838-13-110
Oakite Liquid Bactericide®	sodium hypochlorite	Chemetall	9359-2-1020
Oxine®	chlorine dioxide	Bio-Cide	9804-1
Oxywave®	peroxyacetic acid	Madison Chemical	63838-1-110
Peraclean 15®	peroxyacetic acid	Evonik	54289-4
Peraclean 5®	peroxyacetic acid	Evonik	54289-3
Perasan A®	peroxyacetic acid	Enviro Tech	63838-1
Peroxy-Serve 5®	peroxyacetic acid	Zep	63838-1-1270
Premium Peroxide II®	peroxyacetic acid	West Agro	63838-1-4959
SaniDate 12.0®	peroxyacetic acid	Biosafe Systems	70299-8
Sno-Glo Bleach®	sodium hypochlorite	Brenntag Mid-South	6785-20002
Sobr2®	sodium bromide	Buckman Laboratories	1448-345
Sodium Hypochlorite-12.5 Bacticide®	sodium hypochlorite	Olin Chlor Alkali Products	72315-6
Sodium Hypochlorite 12.5%®	sodium hypochlorite	Alexander Chemical	7151-20001
Sodium Hypochlorite Solution 12.5%®	sodium hypochlorite	KA Steel Chemicals	33981-20001
Sysco Classic Germicidal Ultra Bleach®	sodium hypochlorite	Sysco	70271-13-29055
Tsunami 100®	peroxyacetic acid	Ecolab	1677-164
Vertex Concentrate®	sodium hypochlorite	Vertex Chemical	9616-8
Vertex CSS-10®	sodium hypochlorite	Vertex Chemical	9616-8
Vertex CSS-12®	sodium hypochlorite	Vertex Chemical	9616-7
Vertex CSS-5®	sodium hypochlorite	Vertex Chemical	9616-10
VigorOx 15 F&V®	peroxyacetic acid	FMC	65402-3
VigorOx SP-15 Antimicrobial Agen®	peroxyacetic acid	FMC	65402-3
WSU Sodium Hypochlorite 12.5%®	sodium hypochlorite	Water Solutions Unlimited	33981-20001-83327
Zep Fruit & Vegetable Wash®	peroxyacetic acid	Zep	63838-1-1270

More information about chlorine-based systems and ORP is available in *Oxidation-Reduction Potential (ORP) for Water Disinfection Monitoring, Control and Documentation*, University of California publication 8149, available from <https://anrcatalog.ucanr.edu/>.

## **Waste**

Growers should use caution when using animal-derived soil amendments. Biological soil amendments of animal origin (BSAAO) — soil amendments such as manure, bone meal, or feather meal that are animal-derived — may contain human pathogens. Growers who use raw manure should ensure a lengthy interval between application and harvest. It is generally recommended that growers use a 90-day interval between manure application and harvest for aboveground crops and a 120-day interval for crops where the edible portion is in contact with the soil. Manure is considered raw (or untreated) unless it has been properly composted or has undergone a validated process to reduce microbe levels. Composting must be done in accordance with specifications set forth in the National Organic Standard or materials are considered untreated. Properly composted BSAAO may be applied to fields at any time without application-to-harvest intervals. When using products containing BSAAO, growers should consult the manufacturer to determine if the product has been properly treated.

## **Workers**

Growers should monitor workers for signs of illness. Individuals who are sick should not handle produce and should be assigned to other tasks. Workers should wash their hands frequently, before beginning work and before returning to work following any breaks. Growers should have policies compelling workers to wear clean clothes at the beginning of the workday and prohibiting jewelry (except for a simple wedding band) or sequenced clothing while working with, or around, produce. All workers should receive sanitation and hygiene training.

## **Wildlife**

Excessive wildlife activity in production areas can potentially introduce human pathogens into crops. Growers should monitor fields for signs of wildlife activity. Use interventions when wildlife levels introduce excessive risk to crops. A number of products are available for deterring wildlife from fields. Netting and fencing may be used to exclude animals. Live traps may be used to relocate animals (check local and state regulations first). Reflective tape and noisemaking devices may be used to frighten wildlife. Vertebrate pests

are highly adaptable; as a result, growers will likely need to employ several tactics in combination to manage populations.

## **Produce Safety Rule and On Farm Readiness Review**

The Food Safety Modernization Act (FSMA) Produce Safety Rule became law in January 2016. The rule codifies food safety standards for produce growers. Depending on farm size, growers have varying lengths of time to implement the rule on individual farms. Not all produce growers are covered by the rule, and some growers may have qualified exemptions. The U.S. Food and Drug Administration (FDA) has developed a flowchart to help growers determine whether the rule covers them. The flowchart is available at: <http://www.fda.gov/downloads/Food/GuidanceRegulation/FSMA/UCM472499.pdf>

A series of informational videos dealing with FSMA Produce Rule coverage may be accessed at the Safe Produce Indiana website, <https://ag.purdue.edu/extension/safeproduce/Pages/Learn-about-FSMA-Rules.aspx>

Among other requirements, one person from each farm covered by the Produce Safety Rule must receive training. Produce Safety Alliance (PSA) grower trainings meet the Produce Safety Rule training requirement. A directory of certified trainers is available on the PSA website, <https://producesafetyalliance.cornell.edu/training/directory>

Growers covered by the Produce Safety Rule may also be required to meet certain water testing requirements and criteria. Growers should consult Purdue Extension Publication GP-2-W (available at [www.extension.purdue.edu/extmedia/GP/GP-2-W.pdf](http://www.extension.purdue.edu/extmedia/GP/GP-2-W.pdf)) for water sampling information and a summary of Produce Safety Rule water testing criteria. A list of FDA-approved laboratory testing methods may be found at [https://www.fda.gov/Food/FoodScienceResearch/LaboratoryMethods/ucm575251.htm?source=govdelivery&utm\\_medium=email&utm\\_source=govdelivery](https://www.fda.gov/Food/FoodScienceResearch/LaboratoryMethods/ucm575251.htm?source=govdelivery&utm_medium=email&utm_source=govdelivery)

The On Farm Readiness Review is a tool developed by the National Association of State Departments of Agriculture (NASDA) to help growers assess their level of compliance with the Produce Safety Rule. The review is voluntary, confidential, and conducted by a team of qualified individuals. Growers who wish to request an On Farm Readiness Review should contact the lead agency for Produce Safety Rule implementation in their respective states. Indiana growers should contact the Indiana Department of Health at 317-476-0056 or [ProduceSafety@ISDH.in.gov](mailto:ProduceSafety@ISDH.in.gov) to request a review. Michigan growers should contact [OFRR@msu.edu](mailto:OFRR@msu.edu) or 517-768-2038.

## Inspection of Covered Produce Farms

Inspection of produce farms covered by the FSMA Produce Safety Rule began in 2019. Farms with annual sales of over \$500,000 were initially inspected. During the 2020 growing season, those farms with annual sales of \$250,000-\$500,000 (small farms per FDA definition) will also be inspected. Inspections for very small farms, those having annual sales of \$25,000-\$250,000, will begin in 2021. Inspections will vary by state and may be conducted by state departments of agriculture, state departments of health, or FDA. All inspections will be conducted using a similar process and will be based on FDA Form 4056, although states may customize this form to some degree. A copy of FDA Form 4056 may be viewed at <https://www.fda.gov/media/124867/download>. Regardless of the agency conducting the inspection, growers will be contacted well in advance of the actual inspection in order to arrange a mutually agreed-upon inspection time.

## GAPs Certifications and Third-Party Audits

A GAPs certification (also known as a third-party certification) is an increasingly common condition of sale for many produce buyers. GAPs certifications are not the same as receiving a certificate for attending a GAPs training or proof of completing a PSA Grower Training. GAPs certifications require an audit by an independent (third) party. The audit verifies that growers have implemented GAPs on their farm and are following their written food safety plan. Steps to obtaining a GAPs certification are:

1. Communicate with your buyer. Growers should make sure they understand exactly what buyer requirements are and what audits the buyer will accept. Several different GAPs protocols are available to growers. Make sure you are using a protocol that your buyer will accept.
2. Once a protocol is selected, growers should develop a written food safety plan using the protocol and protocol checklist as a guide.
3. Following preparation of the written food safety plan, growers should implement the plan on their farm.
4. Once the plan is implemented, an auditor is contacted. The auditor visits the farm and verifies the written plan is being followed.
5. Upon successfully completing and passing the audit, the grower receives certification. It is normally valid for one year.



[www.SafeProduceIN.com](http://www.SafeProduceIN.com)

U.S. FDA, [www.fda.gov/food/guidanceregulation/fsma/ucm253380.htm](https://www.fda.gov/food/guidanceregulation/fsma/ucm253380.htm)

GAPsNET, Cornell University, [www.gaps.cornell.edu](http://www.gaps.cornell.edu)

Produce Safety Alliance, <https://producesafetyalliance.cornell.edu>

[https://canr.msu.edu/agrifood\\_safety](https://canr.msu.edu/agrifood_safety)

## Insect Management Strategies

Effective insect and mite management involves at least seven steps:

1. Preventive practices.
2. Properly identifying key pest insects and mites, and beneficial organisms.
3. Selecting and using preventive pest management practices.
4. Monitoring the current status of insect and mite populations.
5. Determining the pest's economic loss potential
6. Selecting the proper pest control option.
7. Evaluating the effectiveness of previously used control options.

## Preventive Insect Management Practices

There are a number of practices that can reduce insect numbers before you actually see the insects in the field. Often, decisions about these practices must be made based on past experience with the insect rather than current knowledge of the severity of the infestation. Many of these practices are good management practices for weeds and diseases as well, so they can easily be incorporated into an overall insect management program.

**Resistant Varieties:** There are not many vegetable varieties that have been bred for insect resistance. However, there are some varieties of cabbage that are resistant to onion thrips. Selection of sweet corn varieties that have husks that completely cover the ear tip and fit tightly around the ear can reduce the amount of corn

earworm damage. Short season varieties of potatoes should be grown when possible to give Colorado potato beetles less time to feed and reproduce. This is not resistance, but it is a method that growers can use to reduce insect damage by varietal selection.

**Crop Rotation:** Rotating crops can reduce the severity of a number of pest problems. Rotating potato fields can greatly increase the amount of time it takes Colorado potato beetles to colonize a field, thereby reducing the time the beetles have to increase to damaging levels. Don't plant crops that are susceptible to wireworm or white grub damage in fields that were previously in sod or heavily infested with grassy weeds. In addition, it is a good idea not to plant cabbage or onions next to small grain fields, because onion thrips build up to very high levels in small grains and may move into cabbage or onions when the small grains dry down or are harvested.

**Crop Refuse Destruction:** Destroying the plant residue after harvest can reduce the damage experienced the next year from a number of insects. Destroying squash and pumpkin vines after completion of harvest can greatly reduce the overwintering population of squash bugs and squash vine borers. Early vine killing in potatoes will reduce the potato beetle populations for the following year.

**Tillage:** Fields that receive reduced amounts of tillage or have some sort of grass windbreaks are often more susceptible to damage from insects such as cutworms and armyworms. These cultural practices may have other advantages that outweigh the potential insect problems, but growers should be aware of the potential for increased insect activity.

**Time of Planting:** Because insects tend to become active at specific times each year, varying the time of planting can sometimes help prevent serious insect problems. Corn earworms and fall armyworms are usually a much more serious problem on late-planted sweet corn. If the option is available, planting sweet corn so that it has no green silks before large numbers of earworm moths are flying can reduce earworm problems. Root maggots are usually more serious during cool, wet weather. Waiting until soil temperatures are adequate for rapid plant growth will help reduce maggot problems.

**Biological Control:** Conserving natural enemies is one aspect of biological control that can effectively reduce pest populations and damage. This can be accomplished in several ways, but the most important is reducing the number of insecticide applications. Each time a spray is applied, more predators and parasites are killed. When deciding to use an insecticide, you should consider the impact that application will have on beneficial insects. *Bacillus thuringiensis* products, for example, do not harm beneficial insects.

## Proper Identification

Properly identifying pests is the foundation on which a good insect management program is built. If the pest is not properly identified, the chances of selecting the correct control strategies are greatly diminished. Many insects and mites can be correctly identified simply because they are encountered so often. However, it never hurts to back up your knowledge base with some reference materials. Your county Extension office has a number of bulletins available that will help you properly identify insect pests. There also are a number of good books available with color photographs of many of the common insect pests. Most entomologists don't like to admit it, but we often identify unfamiliar insects by comparing them to pictures in a book.

As will be discussed in the next section, beneficial organisms can be important components of an effective insect management program. Being able to distinguish the good guys from the bad guys may help you avoid unnecessary and possibly disruptive pesticide sprays. Some common beneficial organisms all growers should be able to identify include lady beetle larvae and adults, lacewing larvae and adults, and syrphid fly larvae.

In addition to proper identification, it is helpful to know as much as possible about the insect's biology. All growers should know the difference between insects with incomplete metamorphosis and those with complete metamorphosis.

Insects with incomplete metamorphosis have juvenile stages — called nymphs — that resemble the adults, except that they are smaller and don't have wings. The feeding behavior is usually the same for nymphs and adults. For example, squash bugs are an insect with incomplete metamorphosis.

Insects with complete metamorphosis have a larval stage that is completely different in appearance from the adult. They also have an intermediate stage, known as a pupa, between the larval and adult stages. Larvae never have wings and are not capable of reproducing. Larvae go through a series of molts (shedding their skins) in order to grow. Larvae and adults frequently, although not always, feed differently. Adult insects never grow, so little beetles don't grow up to be big beetles. For example, caterpillars are larvae. In their adult stage, these larvae become moths or butterflies.

For important insect and mite pests, it also is helpful to know the overwintering stage, life cycle length, and number of generations per year that can be expected. Again, most of this information can be found in Extension bulletins.

## Monitoring

Vegetable growers must make insect and mite pest management decisions on an almost daily basis during the growing season. To make the best decisions, it is often useful to have information regarding the current status of a pest's population. This can be accomplished through some sort of sampling or monitoring program. There are several methods to monitor insect populations.

Pheromone traps can be used to determine when moths are flying. This information can be used in several ways. First, catching moths in the trap can alert growers to begin looking for the pest in the field. This can save time because the grower won't be looking for the pest before it is present. Second, pheromone trap catches can be used to time insecticide applications. Third, for some pests, such as corn earworms, the need to spray can be determined from the number of moths caught in the trap. Pheromones are available for many of the caterpillar pests of vegetables.

The most common method for monitoring insects is by scouting fields. Scouting can be formal, such as counting insects on a given number of plants throughout the field, or it can be informal, with the grower walking through the field and looking for insects on the plants. Formal scouting may be more accurate, but the most important thing is for growers to regularly walk their fields looking for insects or insect damage. Some pests, such as mites, may require the use of a hand lens to see. Others may require the use of equipment such as a sweep net or a beat cloth. Most can be monitored just by close inspection of the plants. Regular (weekly) monitoring will allow growers to make informed management decisions.

## Determining the Potential for Economic Loss

Unfortunately, we do not have economic thresholds for many vegetable insect pests. Whenever possible, we have listed the best thresholds available along with control options in the crop-specific sections of this manual. Although some of these estimates have not been verified by research in each state, they have been derived from scientific research or extensive observations. Growers may wish to adjust these thresholds based on past experience. Extension bulletins also are useful sources of information regarding potential losses from insects. Growers should remember that some crops, such as snap beans and potatoes, can suffer a great deal of defoliation before there is any effect on yield. Sometimes, plants with

considerable amounts of insect damage will yield as well as plants that have no insect feeding. If the pest is one that feeds on the marketable portion of the plant, then less damage can be tolerated.

## Proper Selection of a Pest Control Option

In vegetable crops, the selection of a control option during the growing season usually means doing nothing or selecting a pesticide. Although we always encourage growers to read and follow label directions, the one area where the label is not necessarily the best source of information is concerning which insects the insecticide will control. The insecticides recommended in this book for control of various pests are listed because they are legal to use and because they have been found to be effective by the authors. Consider insecticide costs, application costs, relative effectiveness, gain in profits that can be expected from the application, whether it will control other pests, and how it will affect predators, parasites, and pollinators. Growers should refrain from "revenge spraying," that is, spraying after the damage is already done. At that point, spraying is a waste of money and may actually increase pest damage by killing beneficial insects.

## Evaluation

Growers should always evaluate the effectiveness of a pest control action. Inspecting the field a couple of days after an insecticide is applied will help the grower determine the necessity for additional control measures in that field, as well as provide information about the insecticide's effectiveness for future reference. Growers should pay attention to whether the insecticide killed all stages of the pests or if only small larvae or nymphs were killed. They should also notice the effects on other pests in the field and on beneficial insects.

## Resistance Management

It is important to occasionally rotate products with different modes of action in order to reduce the potential of insect and mite populations developing resistance to products with specific modes of action. A pesticide's mode of action is how it affects the metabolic and physiological processes in the pest (in this case, the pests are insects or mites). Many product labels contain resistance management information or guidelines that will help vegetable growers determine which products they should rotate with others. For more information associated with rotating different modes of action, contact your state or regional extension entomologist.

## Selected Information About Recommended Insecticides

This table includes selected information about the insecticides recommended in this guide. The products are listed alphabetically by the **Trade Name**. The table also lists the **Common Name** of active ingredient.

The **Signal Word** column indicates the product's possible toxicity. If the signal word is set in bold, the product is a restricted use product (RUP). See page 33.

The **IRAC Code** column indicates the product's mode of action. IRAC stands for Insecticide Resistance Action Committee. Refer to product labels for information about alternating fungicide modes of action.

The **Greenhouse Use** column has one of four listings:

*yes*=the product label explicitly allows greenhouse use

*some*=the product label explicitly allows greenhouse use for certain crops (see the label for details)

*no*=the product label explicitly prohibits greenhouse use

*silent*=the product label does not mention greenhouse use — states vary about whether such products are allowed in greenhouse production

The **OMRI** column, products marked with an X are listed by the Organic Material Review Institute (omri.org) and may be suitable for organic production. Check with your certifier. See page 39 for more information.

Trade Name	Common Name	Signal Word	IRAC Code	Greenhouse Use	OMRI
Acramite 50WS®	bifenazate	Caution	-	silent	
Actara 25WDG®	thiamethoxam	Caution	4A	no	
Admire Pro 4.6F®	imidacloprid	Caution	4A	some	
Agree WG®	<i>Bacillus thuringiensis aizawai</i>	Caution	11A	yes	x
Agri-Mek 0.15EC®	abamectin	<b>Warning</b>	6	some	
Agri-Mek 0.7SC®	abamectin	<b>Warning</b>	6	some	
Ambush 25W®	permethrin	<b>Warning</b>	3A	silent	
Ammo 2.5EC®	cypermethrin	<b>Caution</b>	3A	silent	
Asana XL 0.66EC®	esfenvalerate	<b>Warning</b>	3	silent	
Assail 30SG®	acetamiprid	Caution	4A	no	
Assail 70WP®	acetamiprid	Caution	4A	no	
Athena®	bifenthrin + abamectin	<b>Caution</b>	3A + 6	silent	
Avaunt 30WDG®	indoxacarb	Caution	22	some	
Azera®	azadirachtin + pyrethrins	Caution	- + 3A	yes	
Aztec 2.1G®	cylfluthrin + phostebupirim (tebupirimfos)	<b>Warning</b>	3A + 1B	silent	
Baythroid XL 1EC®	beta-cyfluthrin	<b>Warning</b>	3	silent	
Belay 2.13SC®	clothianidin	Caution	4A	silent	
Belay 50WDG®	clothianidin	Caution	4A	silent	
Beleaf 50SG®	flonicamid	Caution	9C	some	
Besiege®	chlorantraniliprole + lambda-cyhalothrin	<b>Warning</b>	28 + 3	no	
Biobit HP WP®	<i>Bacillus thuringiensis kurstaki</i>	Caution	11A	yes	x
Blackhawk®	spinosad	Caution	5	no	
Brigade 2EC®	bifenthrin	<b>Warning</b>	3A	silent	
Brigade WSB®	bifenthrin	<b>Warning</b>	3A	silent	
Capture 1.15G®	bifenthrin	<b>Caution</b>	3A	silent	
Capture LFR 1.5EC®	bifenthrin	<b>Warning</b>	3A	silent	
Confirm 2F®	tebufenozide	Caution	18	silent	

## Selected Information About Recommended Insecticides (continued)

Trade Name	Common Name	Signal Word	IRAC Code	Greenhouse Use	OMRI
Coragen 1.67SC®	chlorantraniliprole	Caution	28	no	
Counter 15G Smartbox®	terbufos	<b>Danger</b>	1B	silent	
Cruiser 5FS®	thiamethoxam	Caution	4A	-	
Cruiser Maxx®	thiamethoxam + fungicides	Caution	4A	-	
CruiserMaxx Potato®	thiamethoxam + fungicides	Caution	4A	-	
Danitol 2.4EC®	fenpropathrin	<b>Warning</b>	3A	silent	
Deadline Bullets 4B®	metaldehyde	Caution	-	silent	
Diazinon 50W®	diazinon	<b>Caution</b>	1B	no	
Diazinon AG500®	diazinon	<b>Caution</b>	1B	no	
Diazinon AG600®	diazinon	<b>Caution</b>	1B	no	
Dibrom 8E®	naled	<b>Danger</b>	1B	yes	
Dimethoate 2.67EC®	dimethoate	<b>Warning</b>	1B	silent	
Dimethoate 400®	dimethoate	<b>Warning</b>	1B	silent	
Dimethoate 4E®	dimethoate	<b>Warning</b>	1B	silent	
DiPel DF®	<i>Bacillus thuringiensis kurstaki</i>	Caution	11A	yes	x
DiPel ES®	<i>Bacillus thuringiensis kurstaki</i>	Caution	11A	silent	
Discipline 2EC®	bifenthrin	<b>Warning</b>	3A	silent	
Durham 3.5G®	metaldehyde	Caution	-	silent	
Durivo®	thiamethoxam + chlorantraniliprole	-	4A + 28	no	
Endigo ZC®	thiamethoxam + lambda-cyhalothrin	<b>Warning</b>	3A + 4A	no	
Entrust 2SC®	spinosad	-	5	some	x
Entrust®	spinosad	Caution	5	some	x
Exirel 0.83SE®	cyantraniliprole	Caution	28	some	
Farmore FI400®	thiamethoxam + fungicides	-	4A	-	
Farmore FI500®	thiamethoxam + spinosad + fungicides	-	4A + 5	-	
Force 3G®	tefluthrin	<b>Caution</b>	3	silent	
Force CS®	tefluthrin	<b>Warning</b>	3	silent	
Fulfill®	pymetrozine	Caution	9B	silent	
Hero®	bifenthrin + zeta-cypermethrin	<b>Caution</b>	3A + 3A	silent	
Intrepid 2F®	methoxyfenozide	Caution	18	some	
Javelin WG®	<i>Bacillus thuringiensis kurstaki</i>	Caution	11A	silent	x
Kanemite 15SC®	acequionycl	Caution	20B	some	
Knack 0.86EC®	pyriproxyfen	Caution	7C	silent	
Kryocide 96D®	cryolite	Caution	8C	silent	
Lannate LV 2.4L®	methomyl	<b>Danger</b>	1A	silent	
Lannate SP®	methomyl	<b>Danger</b>	1A	silent	
Larvin 3.2F®	thiodicarb	<b>Warning</b>	1A	silent	
Lorsban 15G®	chlorpyrifos	Caution	1B	silent	
Lorsban 4E®	chlorpyrifos	<b>Warning</b>	1B	silent	
Lorsban 75WG®	chlorpyrifos	<b>Warning</b>	1B	silent	
Lorsban Advanced 3.755L®	chlorpyrifos	<b>Warning</b>	1B	silent	
M-Pede®	potassium salts of fatty acids	<b>Warning</b>	-	yes	x
Malathion 5®	malathion	<b>Warning</b>	1B	silent	

**Selected Information About Recommended Insecticides** (continued)

Trade Name	Common Name	Signal Word	FRAC Code	Greenhouse Use	OMRI
Malathion 57EC®	malathion	Warning	1B	silent	
Malathion 5EC®	malathion	Warning	1B	silent	
Mocap 15G®	ethoprop	<b>Danger</b>	1B	silent	
Mocap EC®	ethoprop	<b>Danger</b>	1B	silent	
Movento 2SC®	spirotetramat	Caution	23	no	
Mustang Maxx 0.8EC®	zeta-cypermethrin	<b>Warning</b>	3A	silent	
Nealta 1.67SC®	cyflumetofen	Caution	25	no	
Neemix®	azadirachtin	Caution	-	yes	x
Novodor FC®	<i>Bacillus thuringiensis tenebrionis</i>	Caution	11A	silent	
Nuprid 2SC®	imidacloprid	Caution	4A	some	
Oberon 2SC®	spiromesifen	Caution	23	silent	
Orthene 97S®	acephate	Caution	1B	no	
Perm-Up 3.2EC®	permethrin	<b>Caution</b>	3A	silent	
Permethrin 3.2EC®	permethrin	Caution	1B	silent	
Platinum 2SC®	thiamethoxam	Caution	4A	no	
Platinum 75SG®	thiamethoxam	Caution	4A	no	
Platinum Ridomil Gold®	thiamethoxam + fungicides	Warning	4A	silent	
Portal 0.4EC®	fenpyroximate	Warning	21A	no	
Pounce 25WP®	permethrin	<b>Warning</b>	3A	silent	
Proclaim 5SG®	emamectin benzoate	<b>Caution</b>	6	no	
Prokil Cryolite 50D®	sodium aluminoflouride	Caution	-	silent	
Pyrenone Crop Spray®	piperonyl butoxide + pyrethrins	Caution	- + 3A	yes	
Radiant 1SC®	spinetoram	Caution	5	no	
Rimon 0.83EC®	novaluron	Warning	15	some	
Scorpion 35SL®	dinotefuran	Caution	4A	silent	
Sepresto 75WS®	clothianidin + imidacloprid	Caution	4A + 4A	-	
Sevin 4B®	carbaryl	Caution	1A	silent	
Sevin 4SL®	carbaryl	Caution	1A	silent	
Sevin XLR Plus 4F®	carbaryl	Caution	1A	silent	
Sivanto 200SL®	flupyradifurone	Caution	4D	silent	
Sluggo 1B®	iron phosphate	Caution	-	yes	x
Telone II®	1,3-dichloropropene	<b>Warning</b>	-	no	
Thimet 20G®	phorate	<b>Danger</b>	1B	silent	
Torac 15EC®	tolfenpyrad	Warning	21A	silent	
Transform WG®	sulfoxaflor	Danger	4C	no	
Trigard 75WP®	cyromazine	Caution	17	no	
Venom 70SG®	dinotefuran	Caution	4A	silent	
Verimark 1.67SC®	cyantraniliprole	-	28	no	
Voliam Flexi®	thiamethoxam + chlorantraniliprole	Caution	4A + 28	no	
Vydate C-LV®	oxamyl	<b>Danger</b>	1A	silent	
Vydate L®	oxamyl	<b>Danger</b>	1A	silent	
Warrior II 2.08EC®	lambda-cyhalothrin	<b>Warning</b>	3A	silent	
wettable sulfur	sulfur	Caution	-	silent	
XenTari®	<i>Bacillus thuringiensis aizawai</i>	Caution	11A	yes	x
Zeal 72WSP®	etoxazole	Caution	10B	silent	

# Preharvest Intervals (Days) and Re-Entry Intervals (Hours) for Insecticides/Acaracides Registered for Use on Midwest Vegetables 2020<sup>1</sup>

	Acrاميت®	أكتارا®	أدمنير برو®	أجري-ميك®	أمبش®	آسانا®	آسان®/	آفالنت®	باديلوس ثورينجينيتس®	باثرثرويد®	بليز®	بليزف®	بريدج®	كوراجون®	كريوليت®/كريوكيد®	دانيلو®	ديميثوكايت®	إنترسٹ®	إكيريل®	فولفيل®	إنتربيت®	لانتات®	لارفين®	لورشان®	مالاثيون®	مovenتو®	ماستنگ ماس®	نيمنيك®	أوبيرون®	أورثين®	پلاتينوم®	پروclaim®	راديانت®	رينون®	سيفين®	سيانتو®	فينوم®	فينارك®	وليم فلوكس®	وليم اكسبرس®	وليم وارثر®
Asparagus							1	0						1			180	60	110		1	1	1	1		0					60		1								
Beet	7	21						7	0		3		1	1				3				0		7		1	0			X		7	7	7							
Broccoli	0	X		1	3	7	3	0	0	24	0	7	3	7	7	7	1	1	1	7	1	3	7	X	2	1	1	0	7	14	30	7	1	7	3	1	X	X	3	3	1
Brussels Sprouts	0	X		1	3	7	3	0	0	24	0	7	3	7	7	10	1	1	1	7	1	3		X	2	1	1	0	7	14	30	7	1	7	3	1	X	X	3	3	1
Cabbage	0	X		1	3	7	3	0	0	24	0	7	3	14	7		1	1	7	1	1	7	X	7	1	1	0	7		30	7	1	7	3	1	X	X	3	3	1	
Cantaloupe	3	0	21	7	0	3	0	3	0	0	7	0	3	1	14	7	3	3	1	0	3	X		1		1	0	7		30		3	1	3		21	1	1	1	1	
Carrot	7	21		7		0	0		3	21	1				3				14	1			7		1	0			X		3	7	7								
Cauliflower	0	X		1	3	7	3	0	0	24	0	7	3	7	7	7	1	1	7	1	3	7	X	2	1	1	0	7	14	30	7	1	7	3	1	X		3	3	1	
Celery	7	45	7	1		7	3	0	0	X	7	1			7	1			1	7	14		7		1	0		21	30	7	1	14		X	7						
Chinese Cabbage	7	X		1	3	7	3	0	0	X	0	7	3		7		1	1	7	1	10		X	7	1	1	0	7		30	7	1	7	14	1	X	7	3	1		
Collard	7	X		1	7	7	3	0	0	24	0	7	3	14			1	1	7	1	10		X	7	1	1	0			30	14	1	14	1	X	X	7				
Cucumber	3	0	21	7	0	3	0	3	0	0	7	0	3	1	14	7		1	1	0	3	X		1		1	0	7		30		1	1	3		21	1	1	1	1	
Eggplant	3	0	X	7	3	7	3	0	7	7	0	7	1	14	3		1	1	0	1	5			1	1	1	0	1		30	7	1	1	3	X	X	1	1	5	5	
Endive	7	X	7	1		7	0	0	X	0		1			14	1	1	7	1	10		7	3	1	0	7		30	7	1	14	1	X	X	7						
Green Onion		21	30	1		7	0				1	1				1	1		1	7		3	X	7	0													14			
Head Lettuce	7	X	7	1		7	3	0	0	X	0	7	1	14			1	1	7	1	X	14		14	3	1	0	7	21	30	7	1	14	1	X	X	7	1	1		
Kale	7	X				7	3	0	0	24	0	7	3		14	1	1	7	1	10		X	7	1	1	0			30	14	1	14	1	X	X	7					
Kidney Bean	7		X	7		21	7	0	7		14	1			X	28			7	14		X		7	24	0		14			28	1	X	7			24				
Leaf Lettuce	7	X	7	1		7	3	0	0	X	0		1	14		14	1	1	7	1	X	14		14	3	1	0	7		30	7	1	14	1	X	X	7	1	1		
Lima Bean	3		X			7	0				3	1			X	3			7	X	X		1	1	0		1		3	1	X	7			7						
Mint	7	7		28		7	0				3				7			14	14	90	7		0		14		7									7					
Mustard	7	X		7	3	3	7	0	0	24	0	7	3		14	1	1	7	1	10		7	1	1	0			30	14	1	1	14	1	X	X	7					
Okra	3		X			7	0			0	7	1			1	1		1		1			1		1				1	3	1										
Onion Bulb		21	30	1		7	0				1				1	1		7	X	3	X	7	0				1										14				
Parsley	7	X	7	1		7	3	0	0	X	0		1			1	1	7	1	X	14		7	3	1	0	7		30	7	1	14	1	X	X	7					
Parsnip	7	21				0					1				3			1			7		0		X		3	7													
Peas	3		X			3	7	0			3	1		7	X	3			7	1	X	3	1	0													7				
Pepper	3	0	X	7	3	7	7	3	0	7	1	0	7	1	14	3	2	1	1	0	1	3		1	1	1	0	1	7	30	7	1	1	3	X	1	1	5	5		
Potato	14	X	14	14	7	7	7	0	0	14	7	21	14	0		X	7		14	6		0	7	1	0	7		X		7	14	7	X		X	14	14	7			
Pumpkin	3	0	21	7	0	3	0	0	0	7	0	3	1	14	7		3	1	0	3			1	3	1	0	7		30		3	1	3		21	X	1	1	1		
Radish	7	21		7		0	0			21	1							1			X	7		0		X		3	7	7	X										
Rhubarb	7	45	7	1		7	0	0	X	0	7	1			1	1	7	1	14			1	0			30	7	1	14	1		7									
Rutabaga	7	21				0			3	21	1								X		7	1				X		3	7	7											
Snap Bean	3		X			3	7	0			3	1			X	3			7	X	X	0	1	1	0				3	1	X	7			7						
Spinach	7	X	7	1		7	3	0	0	X	0	40	1			1	1	7	1	X	14		7	3	1	0	7		30	7	1	14	1	X	X	7					
Summer Squash	3	0	21	7	0	3	0	0	0	7	0	3	1	7	7		3	1	0	3	X		1	1	0	7		30		3	1	3		21	1	1	1	1			
Sweet Corn						1	1	7	3	0	0		X	1			1			3	0	0	X	5		3	0	5				1	1	2			X				
Sweet Potato	14	X	14	7		7	7	0	0	14	7	21	1			7		14	7			X	3	7	1	0	7		X		7	14	7	7	X	14	7				
Tomato	3	0	X	7	0	1	7	3	0	0	7	0	1	1	14	3	7	1	1	0	1	1		1	1	1	0	1		30	7	1	1	3	X	X	1	1	5	5	
Turnip	7	21		1	7	3	0	0	X	3	21	1			14	3	1	7	1	10		X	1		1	0			X	14	3		7		X						
Watermelon	3	0	21	7	0	3	0	3	0	0	7	0	3	1	14	7	3	3	1	0	3	X		1	1	0	7		30		3	1	3		21	1	1	1	1		
Winter Squash	3	0	21	7	0	3	0	3	0	0	7	0	3	1	14	7		3	1	0	3			1	1	0	7		30		3	1	3		21	1	1	1	1		
Re-Entry Intervals (hours)	12	12	12	12	12	12	12	12	4	12	12	12	12	4	12	12	24	X	4	12	12	4	48	48	X	X	24	12	12	4	X	12	4	12	24	24					

X=check label for details.

\*Check label directions before applying any of these pesticides.

# Plant-parasitic Nematode Management Strategies

1. The soil contains many nematode species and some (but not all) species are parasites of plants and animals. Plant-parasitic nematodes share four common characteristics: Most species are microscopic; all species require microscopic identification. Adults range from about 1/60-1/4-inch long.
2. They are obligate parasites of plants. This means they must have living plant tissue to feed on in order to grow and reproduce.
3. They all possess stylets. Stylets are structures similar to hypodermic needles that nematodes use to puncture plant cells to obtain the contents.
4. They all spend at least part of their life cycle in soil. However, some remain in root or leaf tissue for extended amounts of time.

Every plant species has at least one nematode species that parasitizes it. About 95 percent of all plant-parasitic nematodes feed on roots. Some nematodes feed within leaves. Plant-parasitic nematodes must feed on living host tissue to grow and reproduce. This means that if the host dies, the nematodes will disperse to search for other plants.

Plant-parasitic nematode feeding does not necessarily result in characteristic secondary (aboveground) symptoms. For this reason, nematode problems often go undiagnosed. Typical aboveground symptoms of nematode infections include stunting, yellowing, and wilting. In some situations, nematodes can cause considerable yield losses; however, nematodes can reduce yields without plants showing any noticeable aboveground symptoms.

The best defense against nematodes is to avoid them. Eradicating them from fields is usually not a viable option. Due to their microscopic nature and abundance in soil, avoiding nematodes is nearly impossible, so nematode infestations in some fields are inevitable.

Nematodes can travel long distances on machinery, in plant material, in or on animals, in water, and on the wind. The bottom line: Anything that moves soil, may move nematodes. Many of these factors are uncontrollable. However, growers can control how they move and sanitize their machinery. If field samples

indicate that pathogenic nematode species are present at damage threshold levels, take steps to reduce the population densities of these organisms (see Sampling Nematode Populations, page 59).

Here are five effective tactics for controlling nematode populations.

## Biological Controls

The majority of nematodes in the soil are beneficial. They typically feed on bacteria, fungi, or small animals including other nematodes. Research results indicate that increasing beneficial nematode populations often correlates with a decrease in the numbers of plant-parasitic nematodes. Try to increase the diversity and numbers of these beneficial nematodes in fields. For information, consult bulletins or other publications focused on soil ecology and health.

In addition, many organisms are parasites or pathogens of nematodes. Most of these occur naturally in soils, but they often do not sufficiently control plant-parasitic nematodes enough to keep their population densities below damage threshold levels. Some manufacturers market products as biological nematicides. Such products may help to increase beneficial nematodes to levels that may help manage plant pathogenic nematodes. See Nematicides Labeled for Use on Vegetables 2020 (page 60).

## Chemical Controls

Nematicides are compounds that kill nematodes. There are two main types of synthetic nematicides: fumigants and nonfumigants.

Fumigants are typically sold as liquids that react with water in the soil to produce gases that kill a wide variety of organisms (including plants). They are wide-spectrum biocides. If you fumigate, you should do it in the fall (preferably) or spring when soil temperatures are adequate. Fumigant nematicides labeled for use in vegetable production are shown in Nematicides Labeled for Use on Vegetables 2020 (page 60).

Nonfumigant nematicides do not volatilize in soil water. They can be applied before, during, or even after planting in some situations. These compounds are often not as broad in their spectrum as fumigants. They will control nematodes, but using them will often decrease the numbers of beneficial nematodes, too. Nonfumigants may be less detrimental to beneficial nematodes since some of these compounds are systemic in the plant and thus target pathogenic nematodes.

## Cultural Controls

Cultural nematode management options include choosing crop plants or cover crops that are not hosts for the problem nematode, selecting the optimal planting date, planting companion plants, and so on. We recommend rotating with a non-host. For example, grasses are non-hosts to most root-knot nematodes, so rotating with a grass (such as corn, wheat, etc.) will reduce nematode populations. Using cultural tactics requires you to properly identify which plant-parasitic nematodes are present.

## Genetic Controls

Plant resistance is often the most sustainable control tactic. For example, many tomato varieties have resistance to root-knot nematodes. However, most vegetables do not have resistance against nematodes, and currently, there are no genetically modified varieties available. Some vegetable varieties may better tolerate nematode feeding, but this information is not always readily available.

## Physical Controls

Physical nematode control options include using heat, steam, or water (flooding) to reduce nematode population densities. In field situations, these types of controls are often not feasible in the Midwest. However, in glasshouse or poly-house production, growers may use heat or steam to sterilize growing media.

## Sampling Nematode Populations

Plant-parasitic nematodes are microscopic organisms with aggregate (often highly clumped) distributions in fields. As a result, the symptoms their feeding causes often occur in circular or elliptical patterns. If you observe plant symptoms are uniformly distributed, the cause of the problem is typically not nematodes.

All sound nematode management programs include rigorous sampling. Since nematodes are microscopic and typically do not always produce noticeable symptoms that indicate their presence, it is necessary to sample to detect nematodes and avoid problems.

A great deal of research has gone into sampling nematode populations. Here are three important points:

1. Due to their microscopic nature, the only way to diagnosis a plant-parasitic nematode problem is to collect a soil and/or plant tissue sample(s) and send it to a nematode diagnostic lab for analysis (see Selected University Laboratory Services, page 45). It is critical to properly identify the nematode's genus or species to provide specific management recommendations. Please refer to any bulletin or other publication devoted to sampling for these organisms for more detailed instructions.
2. When collecting soil samples for plant-parasitic nematodes, the more soil cores you can gather, the better the sample. Collecting roughly 20 soil cores is usually adequate. You can combine and mix these cores. A lab usually only requires you to submit a pint to a quart of soil. You should place nematode samples in plastic bags and close them to retain moisture. Keep the samples out of the sun and heat to ensure that nematodes arrive in good condition for identification at the diagnostic lab.
3. Use different methods for different sample areas. It may be a good idea to separate different areas of the field when sampling. For example, high or low areas of the field or changes in soil types may require different samples.

**Nematicides Labeled for Use on Vegetables 2020<sup>1</sup>**

Name	Type <sup>2</sup>	Active Ingredient	Rate	Crops	Comments
ClandoSan 618®	O	crustaceans	1-3 tons/A	all vegetables	Apply on a broadcast basis. Contains 10.4 lbs. N per 100 lbs. of product.
DiTera DF®	B	90% w/w <i>Myrothecium verrucia</i> strain AARC-0255	5.0-38.4 oz./1,000 ft <sup>2</sup>	many vegetable crops	Can be applied to the soil as a pre-plant, post-plant, or at planting.
EarthMAX®	O	4.2% humic acid	1 gal./A	all vegetables	Apply in enough water to cover an acre every 2-4 weeks. Do not use if soil temperatures are below 50°F.
Kontos®	NF	22.4% spirotetramat	No more than 5 fl. oz./A/year	eggplant, pepper, tomato, many leafy vegetables	Applied as a drench or foliar application to vegetable transplants. Not specifically labeled for nematode control.
K-PAM HL® (RUP)	F	54% potassium N-methyldithiocarbamate	62 gals./A	all vegetables	Can be applied by chemigation, soil injection, or surface incorporations when soil temperatures range from 40-80°F. DTP=14-21. Can be used with Telone II®.
Lorsban 15G®	NF	15% chlorpyrifos	4.6-9.2 oz./1,000 row ft.	brassica crops, other leafy vegetables, sweet corn	Labeled for root maggot control. May provide some control of nematodes.
MeloCon WC®	B	6% <i>Paecilomyces lilacinus</i> strain 251	2-4 lbs./A	all vegetables	Can be applied pre-plant, post-plant, or at planting when soil temperatures range from 70-90°F.
Mocap 15G® (RUP)	NF	15% ethoprop	34-60 lbs./A (broadcast), or 0.9-1.4 lbs./1,000 row ft. (banded)	cabbage, corn, cucumber, mint, potato, snap beans	In Michigan, for best results, Apply Mocap® on a broadcast basis and incorporate it into the top 2-4 inches of soil. Product may damage crop.
Mocap EC® (RUP)	NF	69.6 % ethoprop	2.4 -4.4 fl. oz./1,000 row ft. (banded)	cabbage, mint, potato	In-row or broadcast.
Movento®	NF	22.4% spirotetramat	4-10 oz./A	many vegetables	Recommended for insect control. May not be effective as a standalone product for nematode control.
NemaKILL®	O	55% botanical oils	32 oz./A	all vegetables	Apply through drip or overhead irrigation and monthly during the growing season.
Nematec®	O	0.56% plant extracts	2.5 qts./A at planting, plus 1 qt. 30 and 60 DAP	all vegetables	Can be applied as spray, drench, or through drip or sprinkler.
Nematode Control®	O	2.5% geraniol		all vegetables	Apply to the soil on a weekly basis.
Nem Guard Gold®	B	3.3% <i>Bacillus chitinosporus</i>	2 qts./A at planting	all vegetables	Apply at planting and during the growing season.
Nimitz®	NF	40% fluensulfone	3-5 pts./A (broadcast)	many crop groups	Apply a minimum of 7 days before transplanting.
Telone II® (RUP)	F	97.5% 1,3-dichloropropene	9-25 gals./A	all vegetables	Fumigate in the fall when the soil temperature at 6 inches exceeds 50°F. Inject the product at 8 inches and lightly seal after application. [[MERGE 2 DOWN]]
Telone C-17® (RUP)	F	81.2% 1,3-dichloropropene; 16.5% chloropicrin	10-30 gals./A	all vegetables	
Telone C-35® (RUP)	F	63.4% 1,3-dichloropropene; 34.7% chloropicrin	13-36 gals./A	all vegetables	
Vapam HL®	F	42% methyl dithiocarbamate	37.5-75 gal./A	all vegetables	Do not plant for 14-21 days after application. Effective at soil temperatures down to 40°F.
Velum Prime®	NF	41.4% fluopyram	6.5-6.84 fl. oz./A	many vegetables	Apply using chemigation equipment. Do not apply more than 13.7 fl. oz./A/year.
Vydate L® (RUP)	NF	24% oxamyl	do not exceed 24 pts./year	carrot, celery, cucumber, eggplant, melon, onion, peppers, potato, tomato	Can be applied pre-plant or at-planting, and/or as a foliar spray. Nematode control requires higher rates. Supply is extremely limited.

<sup>1</sup>Most of these products have not been field tested in Michigan for their effectiveness. It is always best to consult with a nematologist before using any of these materials. These compounds may not be labeled for use in every state in the Midwest.

<sup>2</sup>Nematicide type: B=biological. F=fumigant. NF=nonfumigant. O=other.

# Weed Management Strategies

Weed management requires a multifaceted approach built on an understanding of weeds and the crop. Weed management may involve nonchemical methods, chemical methods (herbicides), or a combination of the two. The aim of any weed management strategy should be to manage the weed population so it is below a level that will reduce your economic return (economic threshold). It is important to consider the impact of weeds on yield and quality of the current crop, as well as the potential for increasing weed problems in future years if weeds go to seed. Deciding which methods to use depends on environmental concerns, marketing opportunities, desired management intensity, labor availability, weed pressure, and the crop. In some instances, the cost of controlling weeds may be more than the economic return from any yield increase that season. This situation occurs when a few weeds are present or the weeds germinate late in the season. In those instances, the best strategy may be to do nothing, or to do the minimum required to prevent seed production and dispersal. In other situations, weed populations and other considerations may require combining herbicides with nonchemical approaches.

The first step in weed management is to identify the weeds and understand their life cycles. Consult identification guides, such as *Weeds of the North Central States* (University of Illinois Agricultural Experiment Station Bulletin 772), for assistance. Weeds can be categorized by life cycles, and management strategies developed accordingly.

Annual weeds complete their life cycles in one year and reproduce solely by seeds. Annuals can be divided into summer or winter annuals, depending on when they grow. Primary tillage operations often control winter annuals before a crop is planted in the spring. The most common vegetable crop weeds (e.g., barnyard grass,

giant foxtail, common purslane, redroot pigweed, and common lambsquarters) are summer annuals.

Perennial weeds live for more than two years and can reproduce by seed or vegetative structures (stolons, rhizomes, corms, bulbs, tubers, or roots). Because perennial weeds are difficult to manage in vegetable crops, it is usually better not to use a field with severe perennial weed problems.

Many nonchemical weed management methods are common sense farming practices. These practices are of increasing importance due to consumer concerns about pesticide residues, potential environmental contamination from pesticides, and unavailability of many older herbicides.

## Cultural Practices

Farm practices should aim to establish a vigorous crop that competes effectively with weeds. This starts with land selection. A general rule is not to plant vegetables on land with a history of heavy weed infestation, especially perennial weeds. Crop selection can reduce the effects of weed competition. One criterion in selecting a crop should be the weed problems of the field. Plant the most competitive crops in the most weed-infested fields, and the least competitive crops in the cleanest ones. Consider planting heavily infested fields as long-term set-aside acres or in non-row crops such as alfalfa. Permanent cover should help prevent buildup of annual weeds.

Crop rotation is another practice that can reduce weed problems. The characteristics of the crop, the methods used to grow it, and the herbicides used, inadvertently allow certain weeds to escape control. Rotation also affects the weed management tools at your disposal. Rotating between crops will improve crop growth and competitiveness. Related vegetables should not be grown in the same location in successive years (see Botanically Related Vegetables).

## Botanically Related Vegetables

Alliums	Apiums	Corn	Cucurbits	Goosefoot Family	Legumes	Mustard Family	Nightshade Family	Sunflower
Chive	Carrot	Dent corn	Cantaloupe	Beet	Dry bean	Broccoli	Eggplant	
Garlic	Celery	Sweet corn	Cucumber	Chard	Lima bean	Brussels sprout	Pepper	
Leek	Fennel		Pumpkin	Spinach	Pea	Cabbage	Potato	
Onion	Parsley		Summer squash		Snap bean	Cauliflower	Tomato	
Shallot	Parsnip		Watermelon		Soybean	Collards		
			Winter squash			Horseradish		
						Kale		
						Kohlrabi		
						Radish		
						Turnip		

Wild proso millet is an example of a problem weed where rotation is important for management. Rotation from sweet corn to small grains, early-planted peas, or alfalfa almost completely eliminates wild proso millet because these crops are established before the soil is warm enough for wild proso millet seed germination. A rotation from sweet corn to broadleaf crops would allow the use of postemergence grass herbicides to manage wild proso millet.

Once a crop is selected, use adaptive, vigorous varieties resistant to diseases. Disease-infected plants cannot effectively compete with weeds. Varieties suited for cultivation in regions covered by this publication are listed in each crop section of this guide.

Narrower row spacings and proper plant densities assure crop canopy closure. Closed canopies shade out later emerging weeds and prevent germination of weed seeds that require light. Weeds seldom are a problem after canopy closure. Proper row spacing and plant density also allow row cultivation.

Correct planting time is another cultural method that can improve crop competitiveness. Crops can be divided into warm- or cool-season plants, depending on the optimum temperature for their growth. Planting date affects the time until emergence and the crop's early seedling vigor, both of which are important in determining crop competitiveness. Cool-season crops germinate at cooler soil temperatures, so compete better against early emerging weeds than warm-season crops. The Classification of Vegetable Crops According to Their Adaptive Field Temperatures table (below) lists crops according to their adaptation to field temperatures. Time plantings so temperatures are favorable for crop growth. Adequate fertilization and appropriate insect and disease management are important in assuring competitive

crops. Adequate fertility assures rapid, uniform stand establishment and good crop growth, which enhance the crop's competitiveness. Disease management information and insect management information are contained in this guide. While poor insect and disease control reduce a crop's competitiveness, inadequate weed control also can cause insect and disease problems.

Mulching can be useful in managing weeds. Mulches can be classified as either natural (e.g., straw, leaves, paper, and compost) or synthetic (plastics). Because natural mulches are difficult to apply over large areas, they are best for small, specialized areas. Natural mulches should be spread evenly at least 1 to 1.5 inches thick over the soil to prevent light penetration. Natural mulch materials must be free of weed seeds and other pest organisms and be heavy enough so they will not be easily displaced by wind or water. A major advantage of natural mulches is that they add organic matter to the soil and do not need to be disposed of at the end of the season.

Synthetic mulches are easy to apply, control weeds within the row, conserve moisture, and increase soil temperature. Black or clear plastic mulches are the most common and are effective in improving early-season growth of warm-season crops such as tomato, cantaloupe, watermelon, or pepper. Fast early-season growth of these crops improves their competitive ability against weeds. Plastic mulches used in combination with trickle irrigation can also improve water use efficiency.

A disadvantage of plastic mulch is disposal at the end of the season. Many landfills do not accept plastic mulches. Photodegradable plastic mulches have been developed, but their season-long persistence has been a problem, and they degrade into small pieces of plastic that contaminate the environment. Biodegradable plastic mulches are available.

### ***Classification of Vegetable Crops According to Their Adaptive Field Temperatures***

Cool-season		Warm-season	
Hardy <sup>1</sup>	Semi-Hardy	Tender	Very Tender
Asparagus	Carrot	Snap bean	Cantaloupe
Broccoli	Cauliflower	Sweet corn	Cucumber
Cabbage	Chinese cabbage	Tomato	Eggplant
Horseradish	Lettuce		Lima bean
Onion	Potato		Okra
Pea			Pepper
Spinach			Pumpkin
			Squash
			Watermelon

<sup>1</sup>Hardy crops are most tolerant of cool temperatures and frost. Very tender crops are most susceptible to frost and cool temperatures.

## Mechanical Practices

Mechanical weed management relies on primary and secondary tillage implements such as moldboard plows, disks, rotary hoes, and row cultivators. Mechanical weed management starts with seedbed preparation. Few no-till systems have been developed for vegetable crops. No-till suggestions are discussed in the sections on biological practices and reduced tillage systems.

Moldboard plowing is usually the first step in mechanically managing weeds. Moldboard plowing is particularly useful in controlling emerged annual weeds. Rotary hoeing is often an important second step in mechanically managing weeds in large-seeded vegetable crops (sweet corn, snap bean, lima bean, and pea). Rotary hoeing should be done after the weeds germinate but before they emerge. Rotary hoeing does not control large-seeded weeds such as velvetleaf and shattercane.

Once the crop has emerged or transplants are established, a row cultivator can be used to manage emerged weeds. Adjust the cultivator sweeps or teeth to dislodge or cover as many weed seedlings as possible. Seedling weeds can be killed by cultivating 1 to 2 inches deep. Best weed control is obtained with a row cultivator in relatively dry soils by throwing soil into the crop row to cover small weed seedlings. Avoid crop injury from poor cultivation, which will reduce crop yields.

In some vegetable crops, such as asparagus, mowing can be an effective weed management tool. Mowing can prevent weed seed production and kill upright weeds, reducing competition. Mowing must be carefully timed to eliminate perennial, biennial, or annual weeds that would compete strongly in vegetables because of their upright growth habits. Timely, repeated mowing also helps deplete the food reserves (root systems) of perennial weeds.

Mechanical control has many limitations that must be considered when designing weed management systems. Because mechanical management relies on relatively dry soil, a rainy period may prevent the use of mechanical weed management options and lead to severe weed competition. Relying entirely on mechanical practices to manage weeds is labor intensive, and many growers will use herbicides combined with nonchemical approaches to control especially difficult weeds. Some of these difficult-to-control weeds include wild proso millet in sweet corn, Canada thistle, hemp dogbane, field bindweed, quackgrass, and johnsongrass. Newly introduced problem weeds often show up in scattered patches along headlands and field borders. These are best controlled or eradicated with herbicides before large areas are infested.

## Biological Practices

Currently, no management system tools exist in the Midwest for using insects or diseases to control weeds common in vegetable crops. Most biological weed management systems to date have been developed to control problem weeds in rangeland areas in the West. One biological system that has potential in the Midwest is the use of cover crops to suppress weed development. These systems are still experimental, but have promise for reducing herbicide use once they are fully developed.

The most promising cover crop system is winter rye. Winter rye is planted in late summer or early fall and overwinters as a cover crop. In the spring, the rye is killed two weeks prior to planting the desired crop. Rye can be killed using herbicides, or, once it has reached the reproductive stage, by mowing, or rolling and crimping. The rye is left as a mulch on the soil surface, and the crop is no-till planted. The system appears to provide early season control of many annual weeds. To obtain acceptable weed control, additional herbicides and/or mechanical control are usually required. The system should be evaluated in small areas before it is adopted.

The Summary of Nonchemical Weed Management Practices table (page 66) summarizes some nonchemical weed management practices. The most effective weed management system is an integrated approach that combines many different practices. This approach must be adaptive, aiming to prevent weed problems or cope with any that occur.

## Chemical Weed Management Strategies

Several herbicides are often labeled for a particular crop. Scouting your area to determine which weeds are present will allow you to select the herbicides that will give you the best control.

All the herbicides labeled for a crop are not necessarily listed in this guide. If you are unfamiliar with an herbicide, conduct a small test under your environmental conditions and cultural practices before using the herbicide extensively.

## Herbicide Labels

### Always Read and Understand the Herbicide Label Before Use.

Reading the herbicide label is a very profitable use of your time. Information on the label will direct you to the correct uses, application methods, rates, and potential environmental hazards of the product. Follow label directions for the best possible control with minimal crop injury and environmental contamination. The label contains restrictions on use and discusses environmental and soil conditions that affect crop injury, influence the effectiveness of weed control, and can cause nontarget site effects.

### Do Not Use Any Herbicide Unless the Label States That It Is Cleared for Your Particular Use and Crop.

Using a nonregistered pesticide can cause harmful residues in the vegetable crop, which can result in crop seizure and consumer injury. The label also states whether the herbicide is a restricted-use or general-use pesticide. Restricted-use pesticide labels contain a statement that the products are restricted and that only licensed applicators can buy them and supervise their application. The information in this production guide is current as of the date of publication. Watch for notices of changes in the U.S. Environmental Protection Agency (EPA) registration of herbicides in the *Illinois Fruit and Vegetable News* ([ipm.illinois.edu/ifvn](http://ipm.illinois.edu/ifvn)), the *Pest Management and Crop Development Bulletin* ([bulletin.ipm.illinois.edu](http://ipm.illinois.edu)), the *Indiana Vegetable Crops Hotline* ([vegcropshotline.org](http://vegcropshotline.org)), or the *Weed Control Guide for Vegetable Crops* (Michigan State University Extension publication E-0433, available at [msuag.info/E433/index.php](http://msuag.info/E433/index.php)).

## Reduced Tillage Systems

Reduced tillage systems combat soil erosion. These systems often include the use of glyphosate or paraquat outside the normal growing season to control emerged weeds. Weeds should be growing actively, and the application must be made before the crop has emerged. If you are applying glyphosate to control perennial weeds, apply it before the soil is disturbed. After it is applied, glyphosate must be allowed to translocate throughout the perennial weed for several days, or incomplete control may result. Follow glyphosate label directions carefully for rates and timing of applications. If perennial weeds are not a major problem, you can eliminate early weed

flushes by applying glyphosate or paraquat to all weeds that emerge. Plant the crop with minimal working of the soil. Never apply glyphosate or paraquat to an emerged crop because severe crop injury or death will occur.

Glyphosate and paraquat will control most annual broadleaf and grass weeds. Neither herbicide has any soil residual activity, so other weed control measures will be necessary during the growing season. Paraquat will suppress perennials by killing their shoots, but it does not control regrowth of perennial weeds from rhizomes or other underground storage organs. Glyphosate is better for controlling perennials because it will kill shoots and translocate to destroy underground parts. Glyphosate will only suppress some particularly hard-to-control perennials such as bindweed, hemp dogbane, and milkweed. To control these perennials, high application rates, repeat applications of glyphosate (within label guidelines), or mechanical removal may be necessary.

## Herbicide Rates and Guidelines for Use in Vegetable Crops

All herbicide rates given in this guide are in amount of product per broadcast acre. Adjust amounts accordingly for banded applications. Make preemergence applications before weeds emerge or after removing any weeds present. Make postemergence applications after weeds have emerged. Several materials may be used between crop rows if appropriate steps are taken to prevent spray from contacting the crop. Some of these materials require shielded sprayers, while others require hooded sprayers. The herbicide recommendations in this guide do not replace careful reading of current herbicide labels. Re-registration of older herbicides has affected the availability of many products. Some of the older herbicides not re-registered are not listed in this bulletin, but may be available, and old stocks can still be used.

## Environmental and Health Hazards of Herbicides

Herbicides can have nontargeted effects, so it is very important that you educate yourself about these effects and consider them when designing weed management systems. The following section contains discussions of some of the potential environmental and health hazards of herbicides.

## Environmental Hazards

Adverse environmental effects from herbicides can have long-term consequences that are difficult to correct, and must be avoided. Some environmental hazards, such as herbicide drift and carryover, will mainly affect your operation, while other hazards, such as water contamination, affect all residents in the area. The following sections discuss some of the potential hazards and methods to avoid them.

**Herbicide carryover.** Herbicide carryover from persistent herbicides has been a particular problem to vegetable crop growers. Persistence depends on herbicide characteristics (method of degradation, water solubility, and rate of application) and site characteristics (soil type, rainfall, and temperature). Avoid carryover because correcting carryover problems after they have occurred is virtually impossible. The most important method to avoid herbicide carryover is to follow label rotation restrictions. Label Restrictions (in Months) on Rotating to Vegetable Crops (page 67) summarizes some of the label restrictions. Always refer to the label for specific information. If there are differences between the table and herbicide label, always follow label information.

**Herbicide drift.** Another frequent hazard to vegetable growers is crop injury from herbicide drift. Certain herbicides, if not used correctly, can injure nontarget plants. Herbicides such as clomazone (Command<sup>®</sup>), dicamba, and 2,4-D can drift up to a mile and seriously damage grapes, tomatoes, peppers, other vegetables, fruit trees, and ornamental plants. Before spraying clomazone, dicamba, or 2,4-D, survey the area for desirable plants.

Spray only on calm days, and use drift inhibitors when appropriate. Minimize drift by applying herbicides with nozzles that produce large droplets. Use an amine formulation of 2,4-D to reduce vapor drift. Spray clomazone, dicamba, and 2,4-D when the temperature is expected to be lower than 80°F to 85°F for several days after treatment. Avoid applying clomazone to wet soils.

**Spray tank residuals.** Dicamba or 2,4-D residues in spray tanks also can injure susceptible vegetable crops. Carefully follow label directions for cleaning spray equipment after using dicamba or 2,4-D. If possible, do not use the same spray equipment to apply 2,4-D or dicamba that you use to apply other pesticides.

**Herbicide resistance.** More than 180 weed species have developed resistance to one or more herbicides. Herbicide-resistant populations tend to develop when herbicides with the same mode of action for killing

weeds are used every year in the same field. The Herbicide Resistance Action Committee (HRAC) groups herbicides according to their modes of action.

Weeds resistant to herbicides in HRAC Group B (ALS inhibitors) make up 30 percent of the documented resistant biotypes. Sandea<sup>®</sup>, Permit<sup>®</sup>, Matrix<sup>®</sup>, Raptor<sup>®</sup>, and Pursuit<sup>®</sup> are vegetable herbicides in this group. Weeds resistant to herbicides in HRAC Group C1 (Photosystem II inhibitors) make up another 20 percent of the documented resistant biotypes. Atrazine, Sencor<sup>®</sup>, and Sinbar<sup>®</sup> are in this group. Widespread glyphosate use in agronomic crops has led to the development of glyphosate-resistant weeds, although they still only represent 3.5 percent of resistant biotypes.

Approaches that aim to prevent herbicide resistance combine the use of herbicides, mechanical (cultivation), and cultural (crop rotation) weed management practices. It is important to avoid relying on herbicides from a single HRAC group year after year. Rotate between, or use tank-mixes of, herbicides with different modes of action. For example, in asparagus rotate between Sencor<sup>®</sup> and Treflan<sup>®</sup>. Use tillage to control weeds that escape from herbicide applications. To minimize any weed resistance that does occur, it is especially important to scout your fields, paying special attention to any patches of a weed normally controlled by the herbicide. Herbicide labels may contain additional information about avoiding

**Water quality.** Residues of some herbicides such as atrazine, metolachlor, and metribuzin have been found in surface and ground water. Detected levels have normally been low, but contamination of water resources is a growing concern. For example, groundwater contamination from pesticides and nitrates is a particular concern in areas of the Midwest with sandy soils and shallow groundwater.

Factors determining the potential for groundwater and surface water contamination include herbicide solubility in water, rate of degradation, volatility, and tendency for the herbicide to attach to soil particles or organic matter. Herbicides that have high water solubility and long persistence are a particular concern.

Site characteristics (soil type, soil depth, water table depth, slope, and weather) also can lead to contamination of water resources from herbicides. You should be aware of the potential problem of herbicide contamination and take all possible steps to avoid contamination of surface and subsurface water resources.

## Summary of Nonchemical Weed Management Practices

<b>Cultural</b>	
Land selection	Avoid fields with a history of weed problems.
Crop selection	Grow the most competitive crops in fields with histories of weed problems.
Crop rotation	Rotate between vegetables and non-row crops such as alfalfa. Rotate between vegetables in different botanical categories.
Adapted crop varieties	Select crop varieties adapted for your area.
Proper row spacings and plant densities	Use row spacings and plant densities that assure rapid crop canopy closure.
Correct planting times	Plant crops when soil temperatures favor rapid germination and emergence. Do not plant warm-season crops too early in the season.
Appropriate crop management	Vigorous, healthy crops are more competitive against weeds and insects.
Mulch	Natural mulches may be appropriate on small acreages. Synthetic (plastic) mulches are useful to manage weeds within the row in warm-season crops. Consider disposal problems when using plastic mulches.
<b>Mechanical and Thermal</b>	
Moldboard plowing	This can eliminate emerged annual weeds.
Rotary hoeing	This is useful to manage small-seeded weeds in large-seeded crops such as sweet corn, snap bean, lima bean, and pea.
Row cultivator	Dislodge or cover as many weed seedlings as possible. Avoid damaging crop root systems.
Mowing	Mow weeds as soon as flowers appear so no viable weed seed is produced.
Flame weeding	Flame weeding, or using a hot flame to kill weeds, is effective for stale seedbed weed removal or weeds that emerge before the vegetable crop. Flame weeding is effective for weed control in vegetables such as onions, parsnips, and carrots. Some growers have successfully used flame weeding on transplanted onions that are 8-10 in. tall. Sweet corn that has just emerged and potatoes up to 2 in. tall can be flame weeded.
<b>Biological</b>	
Cover crops and living mulches	Cover crops and intercrops can reduce weed pressure in a variety of ways: they can compete with weeds to reduce weed seed production, release allelochemicals that suppress weed seed germination and growth, or produce residue that acts as a mulch to suppress weed growth.
Insect or disease pests or weeds	No current systems use insects or diseases to manage weeds in common vegetables.



The lesions on this sweet corn leaf were caused by drift from a contact herbicide. Reduce the possibility of herbicide drift by paying attention to weather conditions and using nozzles that apply the products in large drops.

**Label Restrictions (in Months) on Rotating to Vegetable Crops<sup>1</sup>**

Herbicide	Tomato	Pea	Snap Bean	Sweet Corn	Cucurbits	Potato	Cole Crops
<b>Soybean Herbicides</b>							
Authority Assist®	30+FB	10	10	18	30+FB	26	18-40V
Authority First®, Sonic®	30+FB	9-12-30+FB,V	30+FB	18	30+FB	18	30+FB
Boundary®	12	8	12	4	12	0	12
Canopy®, Canopy EX®	9-10 <sup>2</sup>	9-12	9-12	18	18-30V	1830	18-30V
Classic®	10 <sup>2</sup>	12	12	18	18-30	30	30
Command®	9	AT	9	9	AT	9	V
Envive®	12 <sup>1</sup>	12	12	18	18-30V	18-30V	18-30V
Extreme®	18-40+FB,V	18-40+FB,V	18-40+FB,V	18-40+FB,V	18-40+FB,V	26	18-40+FB,V
First Rate®	18	9	9	18	18	18	18
Flex Star®	10 <sup>2</sup>	4	0	10	10-12	0	18
Optill®	40+FB	4	4	18	40+FB	26	40+FB
Prefix®	10	10	0	10	18	1	18
Pursuit <sup>3</sup>	40+FB	AT	2	18	40+FB	26	40+FB
Python®	26	4	4	10.5-18V	26	12	26
Raptor®	9	AT	AT	9	9	9	V
Reflex®	10 <sup>1</sup>	4	0	10	10-12	0	18
Sencor®	4	8	18	4	18	12	18
Scepter®	18	18	11-15	18	18	18	18
Spartan®	AT <sup>2</sup>	12	12	18	12	12	12V
Synchrony XP®	9 <sup>2</sup>	9-12	9-12	18	18-30	18	18-30
Valor®	12+FB	3-12+FB	3-12+FB	3-12+FB4	12+FB	12+FB	12+FB
Valor XLT®	12	12	12	18	18	18	18
<b>Corn Herbicides</b>							
Aatrex® and others	NNY	NNY	NNY	AT	NNY	NNY	NNY
Accent®, soil pH < 6.5	10	10	10	10	10	10	10
Accent®, soil pH > 6.5	18	18	18	18	18	18	18
Auron®	18	18	18	AT	18	18	18
Anthem®, Anthem ATZ®	18	11	11	AT	18	4	18
Aim®	AT	AT	AT	AT	V	V	12
Balance Pro®	18V	18V	18V	6	18V	6	18V
Basis®	1	10	10	10	18	AT	18
Beacon®	18	8	8-18	8	18	8-18	18
Bicep I MagnumI®	NNY	NNY	NNY	AT	NNY	NNY	NNY
Callisto®	18	18	18	AT	18	18	18
Camix®	18	18	18	AT	18	18	18
Celebrity Plus®	10-18V	10	10	10-15V	10-18V	10-18V	10-18V
Corvus®	17-24V	17-24V	17-24V	9-17V	17-24V	17-24V	17-24V
Define®	12	12	12	AT	12	1	4-12V
Hornet®	26	10.5-18V	10.5-18V	10.5-18V	26	18	26
Harness Xtra®	NNY	NNY	NNY	AT	NNY	NNY	NNY
Impact®	18	9-18V	9-18V	AT	18	9	18
Lariat®, Bullet®	NNY	NNY	NNY	AT	NNY	NNY	NNY
Laudis®	10	10	10	AT	18	10	18
Leadoff <sup>20</sup>	1	10	10	10	10-18	1	18
Lightning®	40	9.5	9.5	18	40	26	40
Lumax®, Lexar®	18	18	18	AT	18	18	18
Marksman®	NNY	NNY	NNY	NY	NNY	NNY	NNY
Northstar®	18	8	8	8	18	8	18
Permit®	2-8 <sup>1</sup>	9	2-9	3	2-9	9	15-18
Prequel®	18	18	10-18V	10	18	6	18
Princep®	NNY	NNY	NNY	AT	NNY	NNY	NNY
Resolve DF®, ResolveQ®	1-1.5	10	10	10	18	18	18
Revolin Q®	18	18	18	10-15V	18	18	18
Spirit®	10-18V	10V	10V	8V	18	18	18
Steadfast®	10-18V	10	10	10-15V	10-18V	10-18V	10-18V
Stinger®	18	18	18	AT	18	18	AT
Surestart®	26+FB	NY	26+FB	10.5-18V	26+FB	40+FB	26+FB
Surpass®, TopNotch® Ful-Time®	NNY	NNY	NNY	NY	NNY	NNY	NNY
Zidua®	18	4-11	11	0	18	4	18

<sup>1</sup>AT=anytime herbicide labeled for the crop or no rotation restriction exists, FB= field bioassay required before planting the crop, NY=the crop can be planted the year after application, NNY= not next year, the crop cannot be planted the following year, V=variable, intervals vary by crop variety or other conditions specified on label.

<sup>2</sup>Transplanted tomatoes only.

<sup>3</sup>In Indiana, the replant restriction for transplanted tomatoes and peppers, cabbage, melons, and cucumbers is 18 months.

**Relative Effectiveness of Herbicides for Vegetable Crops<sup>1</sup>****Ratings Key**

G=Good

F=Fair

P=Poor

N=None/None Labeled

		Barnyardgrass	Crabgrass	Fall Panicum	Foxtails	Goosegrass	Yellow Nutsedge	Morningglory Annual	Galinsoga	Jimsonweed	Lambsquarters	Nightshade	Pigweed	Purslane	Common Ragweed	Smartweed	Velvetleaf
Preplant Incorporated Herbicides	Balan <sup>®</sup>	G	G	G	G	G	P	P	P	P	F	P	G	P	P	P	P
	Devrinol <sup>®</sup>	G	G	G	G	G	N	N	P	N	F	N	G	G	N	P	N
	dimethenamid-P	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N
	Eptam <sup>®</sup>	G	G	G	G	G	F	P	P	N	F	F-P	G	G	P	P	F
	pendimethalin	G	G	G	G	G	N	N	N	N	G	P	G	G	P	P	P
	Prefar <sup>®</sup>	G	G	G	G	G	N	N	N	N	F	N	F	F	N	N	N
	Ro-Neet <sup>®</sup>	G	G	G	G	G	F	N	F	N	F	P	G	F	P	P	P
	s-metolachlor	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N
	Sonalan <sup>®</sup>	G	G	G	G	G	N	N	N	N	F-G	F	F-G	F-G	N	P	N
	trifluralin	G	G	G	G	G	N	F	N	N	G	P	G	G	P	P	P
Preemergent Surface Applied Herbicides	acetochlor	G	G	G	G	G	P	G	P	G	G	G	G	F	F	P	P
	acetochlor+atrazine	G	G	G	G	G	F	G	G	G	G	G	G	G	G	F	
	Auron <sup>®</sup>	G	G	G	G	G	F	G	G	G	G	G	G	G	G	G	G
	alachlor	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N
	Anthem <sup>®</sup>	G	G	G	G	G	P	F	N	F	F	G	G	G	F	P	F
	Anthem ATZ <sup>®</sup>	G	G	G	G	G	F	F	G	G	G	G	G	G	G	G	F
	atrazine	G	G	P	F	G	F	F-G	G	G	G	G	G	G	G	G	F
	Callisto <sup>®</sup>	N	N-P	N	N	N	N	F	G	G	G	G	G	N	P	G	G
	Camix <sup>®</sup>	G	G	G	G	G	G	F	G	G	G	G	G	F	G	G	G
	Chateau <sup>®</sup>	F	F	F	F	F	N	G	N	G	G	G	G	G	G	G	G
	Command <sup>®</sup>	G	G	G	G	G	N	F	P	F	G	P	P	G	G	G	G
	Curbit <sup>®</sup>	G	G	G	G	G	N	N	F	N	F	F	G	G	P	P	N
	Dacthal <sup>®</sup>	G	G	G	G	G	N	N	P	P	F	N	F	F	N	N	N
	Define <sup>®</sup>	G	G	G	G	G	F	N	N	N	F	F	F	G	F	N	N
	dimethenamid-P	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N
	halosulfuron	P	P	P	P	P	G	N	G	P	G	P	G	F	G	G	G
	Karmex <sup>®</sup>	G	F	F	G	G	P	G	G	G	G	G	G	G	G	G	G
	Kerb <sup>®2</sup>	F	F	P	F	F	P	P	P	P	F	P	P	P	G	F	P
	League <sup>®</sup>	F	F	N	F	N	G	N	G	N	G	F	G	G	G	N	N
	Lexar <sup>®</sup>	G	G	G	G	G	F	G	G	G	G	G	G	G	G	G	G
	linuron	F	F	F	F	F	N	P	G	F	G	F	G	G	G	G	G
	Lumax <sup>®</sup>	G	G	G	G	G	F	G	G	G	G	G	G	F	G	G	G
	Matrix <sup>®</sup>	G	P-F	G	G	G	P	P	N	F	F	P	G	F	P-F	F	F
	metribuzin	F	F	F	F-G	F	N	N	G	F	G	N	G	G	G	G	G
	oxyfluorfen	P	F	F	P	P	N	F	G	F-G	G	G	G	G	G	F	
	pendimethalin	G	G	G	G	G	N	N	N	N	G	P	G	G	P	P	P
	Pursuit <sup>®</sup>	P	P	P	G	P	P	P	G	F	F	G	G	P	G	F	F
	Sinbar <sup>®</sup>	G	G	G	F-G	G	P	F-G	G	G	G	F-G	G	G	G	G	G
	Sharpen <sup>®</sup>	N	N	N	N	N	N	P-F	G	F-G	G	G	F-G	G	G	G	G
	s-metolachlor	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N
	Solicam <sup>®</sup>	G	G	G	G	G	F	N	G	N	F	F	F	F	G	F	F
	Spartan <sup>®</sup>	F	F	F	F	F	G	G	G	G	G	F	G	G	N	G	F
	Strategy <sup>®</sup>	G	G	G	G	G	N	F	P	F	G	P	F	F	F	F	G
	Zidua <sup>®</sup>	G	G	G	G	G	F	P	G	P	F	G	G	G	P	P	N
Postemergent Herbicides	2,4-D	N	N	N	N	N	N	N	G	G	F	G	G	P	G	P	F
	Aim <sup>®</sup>	N	N	N	N	N	N	N	G	N	N	G	F-G	N	F	F	G
	Anthem <sup>®</sup>	P	P	P	P	P	P	P	G	N	G	F	F	N	P	F	G
	atrazine + oil	G	G	F	F-G	G	G	F-G	G	G	G	G	G	G	G	G	G
	bentazon	N	N	N	N	N	N	G	F	G	G	F	P	P	F-G	F	G
	bromoxynil	N	N	N	N	N	N	N	G	N	G	G	F	P	G	G	G
	Cadet <sup>®</sup>	N	N	N	N	N	N	N	N	N	F	F	F	F	N	N	G
	Callisto <sup>®</sup>	N	N-P	N	N	N	N	F	G	G	G	G	G	N	F	G	G
	clethodim	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
	clopyralid	N	N	N	N	N	N	N	G	G	P	F	P	N	G	F	N
	dicamba	N	N	N	N	N	N	N	G	G	F	G	G	G	G	G	G
	Evik <sup>®3</sup>	G	G	G	G	G	F	G	G	G	G	F	G	F	G	G	G
	fomesafen	N	N	N	N	N	N	N	N	N	N	N	F-G	N	N	F-G	N
	Fusilade <sup>®</sup>	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
	glyphosate	G	G	G	G	G	F	G	G	G	G	G	G	G	G	G	G
	halosulfuron	N	N	N	N	N	N	G	F	G	N	P	N	F-G	N	G	F-G
	Impact <sup>®</sup>	F	F	P	P-F	F	N	P	G	G	G	G	G	N	G	G	G
	Laudis <sup>®</sup>	G	G-F	F	F-G	G	N	F	G	P	G	G	G	N	G	G	G
	League <sup>®</sup>	F	F	N	N	N	G	G	G	N	N	N	G	G	N	F	N
	linuron	F	F	F	F	F	N	G	G	F	G	G	G	G	G	G	G
	Matrix <sup>®</sup>	G	P-F	G	G	G	F	F	N	F	F	P	G	F	P-F	F	F
	metribuzin	F	F	F	F	F	N	F-G	G	F	G	P	G	G	G	G	G
	nicosulfuron	G	P	G	G	G	P	G	P	G	P-F	P	G	P	P	G	P
	Option <sup>®</sup>	G	F	G	G	G	P	F	P	G	G	G	G	G	G	F	G
	oxyfluorfen	P	P	P	P	P	N	F	G	G	F	G	F	G	F	G	F
	paraquat	G	G	G	G	G	G	F-G	G	G	G	G	G	G	G	G	G
	Poast <sup>®</sup>	G	F-G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
	quizalofop	G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N
	Raptor <sup>®</sup>	G	G	N	G	N	P-F	P-F	N	G	F	G	G	F	P-F	G	G
	Revulin Q <sup>®</sup>	G	F	G	G	N	P	F	G	G	G	G	G	N	F	G	G
	Shieldex <sup>®</sup>	F	G	N	G	F	N	F	N	N	G	F	G	N	G	F	G
	Spin-aid <sup>®</sup>	N	N	N	N	N	N	F	G	F	G	F	P	G	G	G	F
	Starane <sup>®</sup>	N	N	N	N	N	N	G	N	F	P	F	P	G	G	P	G
	Thistrol <sup>®</sup>	N	N	N	N	N	N	F	N	N	F	N	F	N	N	F	N

<sup>1</sup> For pre-packaged mixtures, see ratings for individual components.<sup>2</sup> Excellent against quackgrass.<sup>3</sup> Post-directed spray.

## Selected Information About Recommended Herbicides

This table includes selected information about the herbicides recommended in this guide. The products are listed alphabetically by the **Trade Name**. The table also lists a **Common Name** of active ingredient.

The **Usage** column indicates when the product is applied: preplant incorporated (ppi — applied before weeds emerge and mechanically incorporated into soil), preemergence (pre — applied before weeds emerge), or postemergence (post — applied after weeds emerge).

The **Signal Word** column indicates a product's possible toxicity. If the signal word is set in bold, the product is a restricted use product (RUP). See page 33.

The **WSSA/HRAC Code** column indicates the product's mode of action. WSSA/HRAC stands for Weed Science Society of America/Herbicide Resistance Action Committee Mode of Action Classifications: [hracglobal.com/tools/classification-lookup](http://hracglobal.com/tools/classification-lookup).

The **Runoff/Leaching Potential** column provides ratings from the USDA-NRCS WIN-PST Pesticide Properties database: [go.usa.gov/Kok](http://go.usa.gov/Kok). There are three ratings for potential runoff/leaching:

1=high

2=intermediate

3=low

Trade Name	Common Name	Usage	Signal Word	WSSA/HRAC Code	Runoff/Leaching Potential
Aatrex 4L*	atrazine	ppi, pre, post	<b>Caution</b>	5/C1	2/1
Accent*	nicosulfuron	post	Caution	2/B	3/1
Aim EC*	carfentrazone	post	Caution	14/E	3/3
Assure II*	quizalofop	post	<b>Danger</b>	1/A	1/2
Banvel*	dicamba	post	Caution	4/O	3/1
Basagran*	bentazon	post	<b>Danger</b>	6/C3	3/1
Cadet*	fluthiacet-methyl	post	Warning	14/E	3/3
Callisto*	mesotrione	post	Caution	27/F2	3/1
Caparol*	prometryn	pre, post	Caution	5/C1	2/2
Casoron*	dichlobenil	pre	Caution	20/L	
Chateau SW*	flumioxazin	pre	Caution	14/E	2/3
Clarity*	dicamba	post	Caution	4/O	3/1
Clethodim 2E*	clethodim	post	Caution	1/A	3/3
Command 3ME*	clomazone	pre	Caution	13/F4	3/2
Curbit EC*	ethalfluralin	ppi, pre	<b>Danger</b>	3/K1	1/3
Dacthal W-75*, Dacthal Flowable*	DCPA	pre	Caution	3/K1	1/3
Devrinol DF-XT*	napropamide	ppi, pre	Caution	15/K3	2/2
Dual Magnum*	metolachlor (s-)	ppi, pre	Caution	15/K3	2/1
Eptam 7E*	EPTC	ppi	Warning	8/N	3/3
Firestorm*	paraquat	post	<b>Danger/Poison</b>	22/D	1/3
Formula 40*	2,4-D	post	<b>Danger</b>	4/O	3/1
Fusilade DX*	fluazifop-P	post	Caution	1/A	2/3
Goal XL*	oxyfluorfen	pre, post	Warning	14/E	2/3
Goaltender*	oxyfluorfen	pre, post	Warning	14/E	2/3
Gramoxone SL*	paraquat	post	<b>Danger/Poison</b>	22/D	1/3
Harness*	acetochlor	ppi, pre	Warning	15/K3	3/2
Impact*	topramezone	post	Caution	27/F2	2/1

*continued next page*

**Selected Information About Recommended Herbicides** (continued)

Trade Name	Common Name	Usage	Signal Word	WSSA/HRAC Code	Runoff/Leaching Potential
Karmex <sup>*</sup>	diuron	pre, post	<b>Caution</b>	7/C2	2/2
Kerb SC <sup>*</sup>	pronamide	pre	<b>Caution</b>	3/K1	2/1
Laudis <sup>*</sup>	tembotriione	post	Caution	27/F2	2/1
League <sup>*</sup>	imazosulfuron	pre, post	Caution	2/B	3/2
Liberty 280SL <sup>*</sup>	glufosinate	post	Warning	10/H	3/3
Lorox DF <sup>*</sup>	linuron	pre, post	Caution	7/C2	2/2
Matrix SG <sup>*</sup>	rimsulfuron	pre, post	Caution	2/B	3/2
Micro-Tech <sup>*</sup>	alachlor	ppi, pre	<b>Caution</b>	15/K3	3/2
Moxy 2E <sup>*</sup>	bromoxynil	post	Warning	6/C3	2/3
Nortron SC <sup>*</sup>	ethofumesate	pre, post	Caution	8/N	3/2
Optill <sup>*</sup>	saflufenacil+imazethapyr	pre, post	Caution	14/E and 2/B	2/1
Option <sup>*</sup>	foramsulfuron	post	Caution	2/B	3/2
Outlook <sup>*</sup>	dimethenamid-p	ppi, pre	Warning	15/K3	3/2
Permit <sup>*</sup>	halosulfuron	post	Caution	2/B	3/2
Poast <sup>*</sup>	sethoxydim	post	Warning	1/A	3/3
Prefar 4E <sup>*</sup>	bensulide	ppi	Caution	8/N	1/2
Prowl 3.3EC <sup>*</sup>	pendimethalin	ppi, pre	Caution	3/K1	1/3
Prowl H2O <sup>*</sup>	pendimethalin	ppi, pre	Caution	3/K1	1/3
Pursuit <sup>*</sup>	imazethapyr	ppi, pre, post	Caution	2/B	2/1
Quinstar 4L <sup>*</sup>	quinclorac	post	Caution	4/O	2/1
Raptor <sup>*</sup>	imazamox	pre, post	Caution	2/B	2/1
Reflex <sup>*</sup>	fomesafen	post	<b>Danger</b>	14/E	2/1
Reglone <sup>*</sup>	diquat	post	Caution	22/D	1/3
Rely 280 <sup>*</sup>	glufosinate	post	Warning	10/H	3/3
Ro-Neet	cycloate	ppi	Caution	8/N	3/2
Roundup Ultra <sup>*</sup> , others	glyphosate	post	Caution	9/G	1/3
Sandeia <sup>*</sup>	halosulfuron	post	Caution	2/B	3/2
Scythe <sup>*</sup>	pelargonic acid	post	Warning	26/Z	3/3
Select Max <sup>*</sup>	clethodim	post	Caution	1/A	3/3
Sharpen <sup>*</sup>	saflufenacil	pre	Caution	14/E	3/2
Shieldex <sup>®</sup> 400 SC	tolpyralate	post	Caution	27/F2	N/A
Sinbar WDG <sup>*</sup>	terbacil	pre, post	Caution	5/C1	2/1
Solicam DF <sup>*</sup>	norflurazon	pre	Caution	12/F1	2/2
Spartan 4F <sup>*</sup>	sulfentrazone	pre, post	Caution	14/E	2/1
Spin-Aid <sup>*</sup>	phenmedipham	post	<b>Danger</b>	5/C1	2/3
Spur <sup>*</sup>	clopyralid	post	Caution	4/O	3/1
Starane Ultra <sup>*</sup>	fluroxypyr	post	Warning	4/O	2/3
Stinger <sup>*</sup>	clopyralid	post	Caution	4/O	3/1
Surpass EC <sup>*</sup>	acetochlor	ppi, pre	Warning	15/K3	3/2
Targa <sup>*</sup>	quizalofop	post	<b>Danger</b>	1/A	1/2
Thistrol <sup>*</sup>	MCPB	post	Warning	4/O	3/1
Treflan 4EC <sup>*</sup>	trifluralin	ppi	Caution	3/K1	1/3
TriCor DF <sup>*</sup> , others	metribuzin	pre, post	Caution	5/C1	3/1
UpBeet <sup>*</sup>	triflusulfuron	post	Caution	2/B	3/3
Valor <sup>*</sup>	flumioxazin	pre	Caution	14/E	2/3
Weedar 64 <sup>*</sup>	2,4-D	post	<b>Danger</b>	4/O	3/2
Zidua <sup>*</sup>	pyroxasulfone	pre	Caution	15/K3	3/2

**Preharvest Intervals (Days) and Entry Intervals (Hours) for Herbicides Registered for Use on Midwest Vegetables in 2020<sup>1</sup>**

		2,4-D	acetochlor	acetochlor+atrazine	Auron®	Aim®	alachlor	Anthem®, Anthem ATZ®	Assure II®/Targa®	atrazine	atrazine+dimethenamid-P	atrazine+s-metolachlor	Balan®	bentazon	bromoxynil	Cadet®	Callisto®	Caparol®	Casoron®	Chateau®	clethodim	clopyralid	Command 3ME®	Curbit®	Dacthal®	Devrinol®	dicamba	dimethenamid-P	duron	Eptam®	Expert®	fomesafen	Fusilade®	glyphosate	Goal®, Galigan®					
Asparagus	X				5											X				X	1	14		X	1	X				1	X									
Beet					X																30	30									X									
Broccoli					X																30			X							X	X								
Cabbage					X																30	45	X								X	X								
Cantaloupe					X																14	X	X	X							X									
Carrot					X															30	30										45	X								
Cauliflower					X															30			X								X	X								
Celery																				40																				
Collard						X															14			X								X								
Cucumber					X															14	45	X										X								
Dry Bean					X	30														30											70	X	45	60	X					
Eggplant					X															20			X	X								X								
Endive/Escarole					X																14											X								
Garlic					X											112				X	45										30		45	X	60					
Horseradish					X																30			X								X								
Kale					X																14			X								X								
Leek					X																14			X								14	X							
Lettuce					X										X						X											14	X							
Lima Bean					X												30					30											X							
Mint		40				30										X	70				80	21	45	84										X	X					
Mustard						X															14			X									X							
Okra					X														14														X							
Onion, dry bulb					X													X			45	45										X	30		45	X				
Onion, green bunching					X													X			14			X								30			14	X				
Parsley					X														30		14																X			
Parsnip																				30																		X		
Pea					X	30											30						21															X		
Pepper					X														20		X		X														X			
Potato					X														30														40	45	70	X				
Pumpkin					X															14			X															X		
Radish					X															15																		X		
Rhubarb					X													X	40	X	30		X													14	X			
Snap Bean					X	15											30				21	45														X	30	X		
Spinach					X															14	21																		X	
Squash					X															14	45	X																	X	
Sweet Corn	X	X	X	X	X	X	X	X	X	50	X	X	X			40	45				30										50		X		X					
Sweet Potato						X															30	95	X																14	X
Tomato					X															20			X	X															X	
Turnip, greens					X															14	15			X																X
Turnip, root					X															30	30			X															X	
Watermelon					X															14		X	X	X															X	
Re-Entry Intervals (hours)	48	12	12	24	12	12	12	12	12	12	12	24	12	12	12	12	12	12	12	12	12	12	24	12	12	12	24	12	12	12	24	12	12	24						

continued next page

Preharvest Intervals (Days) and Entry Intervals (Hours) for Herbicides Registered for Use on Midwest Vegetables in 2020<sup>1</sup> (continued)

	halosulfuron	Impact <sup>®</sup>	Kerb <sup>®</sup>	Laudis <sup>®</sup>	League <sup>®</sup>	linuron	Matrix <sup>®</sup>	metribuzin	nicosulfuron	Optill <sup>®</sup>	Option <sup>®</sup>	paraquat	Poast <sup>®</sup>	Prefar <sup>®</sup>	Priority <sup>®</sup>	pendimethalin	Pursuit <sup>®</sup> , Thunder <sup>®</sup>	Pyramin <sup>®</sup>	Quinclorac <sup>®</sup>	Rapto <sup>®</sup>	Revulin Q <sup>®</sup>	Ro-Neet <sup>®</sup>	Sandes <sup>®</sup> or Profine 75 <sup>®</sup>	Sharpen <sup>®</sup>	Shieldex <sup>®</sup>	Sinbar <sup>®</sup>	s-metolachlor	Solican <sup>®</sup>	Sonalam <sup>®</sup>	Spartan <sup>®</sup>	Spartan Advance <sup>®</sup>	Spartan Charge <sup>®</sup>	Spin-Aid <sup>®</sup>	Starane <sup>®</sup> , Starane Ultra <sup>®</sup>	Strategy <sup>®</sup>	Thistrol <sup>®</sup>	trifluralin	Valor <sup>®</sup>	Zidua <sup>®</sup>					
Asparagus						1	14			6	1								X																									
Beet											60							X				X												60										
Broccoli												30	X	60																					X									
Cabbage												X	30	X	70																				X									
Cantaloupe						48						X	14	X	35							57				X									X									
Carrot							14	60				30			X												64								X									
Cauliflower												30	X	70																					X									
Collard												30	X	21																					X									
Cucumber												14	X										30			X									45									
Dry Bean												X	30		X	60		X			30			X		X								X										
Eggplant												X	20	X								30													X									
Endive/Escarole						56						15	X																						X									
Garlic												X	30	X	45																													
Horseradish												60																																
Kale												30	X	21																							X							
Leek												30			30																													
Lettuce						55						X	15-30	X																														
Lima Bean												15		X			X			30			X														X							
Mint												20			X																							40	X					
Mustard												30	X	21																							X							
Okra												14									30			60													X							
Onion, dry bulb												60	30	X	45																					60								
Onion, green bunching												30			30																													
Parsley						30						15	X																															
Parsnip						X						14																																
Pea												X		15		X	X		X			X			X			X			X	X	X			X								
Pepper						21						X	20	X	X						30			X												X								
Potato						45	X	60	60			30		X																								X						
Pumpkin												X	14	X							30			30																X				
Radish												14																													X			
Rhubarb												30																																
Snap Bean												15			X			X			30			X																X				
Spinach												15																														50		
Squash												X	14	X							30			30																45				
Sweet Corn	30	45	X			X		45	X	30		30	X							45	30		35	X											31		37							
Sweet Potato																																											X	
Tomato								21	45	7		30	20		X						30			90		X												X						
Turnip, greens												14			21																													
Turnip, root												14																																
Watermelon						48					X	20	X	35						57			70	60																X				
Re-Entry Intervals (hours)	12	12	24	12	12	24	4	12	4	12	12	12-24	12	12	12	24	12	12	12	12	4	12	12	12	12	24	12	24	12	12	24	12	24	12	12	24	12	12	12					

X=check label for details.

<sup>1</sup>Check label directions before applying any of these pesticides.

# Disease Management Strategies

Plant diseases are caused by a wide variety of microbial pathogens (including fungi, bacteria, viruses, and nematodes). For a plant disease to occur, three components must be present:

1. The pathogen
2. A susceptible host (the plant)
3. An environment conducive to disease.

In addition, insects spread some diseases, which makes them a fourth component of the disease cycle. Disease management strategies target one or more of those factors to prevent and/or reduce the risk of disease. The sections below provide a broad overview of general management strategies. The crop-by-crop chapters go into much more detail for each disease.

## Disease Diagnosis

Before making any management decisions, always make sure to correctly diagnose your problem first. Accurate diagnoses can save time and money because some diseases look alike but have very different management strategies.

Different pathogens have different modes of both survival and spread. Therefore, certain management practices will work for some diseases but may have no effect on others. Furthermore, disease control materials are usually effective against only a subgroup of specific diseases. For example, fungicides will have no effect on viruses.

Moreover, even among the various fungi, some materials may be effective against certain diseases but not others. In particular, the pathogens *Pythium*, *Phytophthora*, and the causal agents of downy mildews that we often discuss as fungi are not true fungi, they are in a different group of organisms called oomycetes. Many materials effective against true fungi are not effective for those organisms, and vice versa.

For example, numerous materials used to manage downy mildew will have no effect or a negligible effect on powdery mildew, and vice versa. A root disease may require very different management compared to a leaf spot or fruit disease.

Moreover, there are several plant health issues that mimic plant diseases (including environmental stress, nutritional problems, herbicide injuries, air pollution, and others). These are known as abiotic disorders. Unwittingly treating a nutrient deficiency with pesticides wastes time and money, and does not solve the

underlying condition. Submitting samples to a diagnostic laboratory is the best way to ensure the correct diagnosis. For a list of labs and instructions on how to submit plants, see pages 45-46.

## Healthy Plant Material

Contaminated seed or transplants can introduce diseases, so saving vegetable seeds for next year's crop is not recommended unless you are trained and equipped to handle seed sanitation (see page 26). You should not save seeds when a seedborne disease has been active. Summary of Cultural Management Strategies for Disease (page 76) lists some diseases that may be transmitted by seed to transplants.

Whether you purchase transplants or produce them yourself, you should read Transplant Production (page 23) to better understand transplant health. Be certain to inspect seedlings regularly. Examine the foliage and remove a few plants from the pots to inspect the roots. If you purchase transplants, keep newly-arrived materials away from other plants and the production area for a few days to prevent spread if a problem is found.

Talk to your supplier and ask questions about how the reduce disease risk. If you suspect a disease on received plants, take photos and contact a diagnostic laboratory (pages 45-46), and continue to keep the plants separate. Keep good records of where plants are sourced from so that you can contact the supplier if a problem arises.

## Disease-resistant Varieties

Whenever possible, use varieties resistant to diseases. Some varieties may not be completely resistant to particular diseases; however, incomplete or partial resistance may be available. Some seed catalogs may refer to tolerance. Summary of Cultural Management Strategies for Disease (page 76) presents information about the availability of resistant varieties.

For certain vegetables (such as tomatoes) there are rootstocks available with resistance to some soilborne pathogens. A resistant rootstock may be an option if you have a history of a known soilborne disease but wish to grow a tomato scion variety that is susceptible.

## Tillage and Crop Rotation

If a disease pathogen survives from year-to-year in crop residue or soil, then crop rotation and fall tillage are very effective factors in disease management. The pathogens are unable to survive once the crop residue decomposes.

Tillage (especially fall tillage) helps control diseases by reducing the amount of inoculum (pathogen structures) that survives the winter. Rotating fields to different crop families each year also helps control diseases by preventing the build-up of certain plant pathogens in the soil. Summary of Cultural Management Strategies for Disease provides tillage and crop rotation recommendations. A general rule is that you should not rotate a field to a crop in the same botanical family. Botanically Related Vegetables (page 61) identifies botanically related crops.

Unfortunately, there are several kinds of soilborne diseases that are unaffected by rotation. The first group of these diseases is caused by pathogens that produce resilient survival structures that can withstand the effects of time and nonhost crops. Two such diseases are Fusarium wilt, and root-knot nematode.

Another group of diseases unaffected by crop rotation has a broad host range, so they can survive indefinitely on many host crop and weed species. Examples include Sclerotinia, Rhizoctonia, and Verticillium diseases.

In addition, root-knot nematode can cause disease in multiple vegetable plant families (cucurbits, tomato, carrot, and many more) along with some field crops and even weeds.

The third group of diseases unaffected by rotation overwinter in Gulf Coast states, and then spread north by wind during the growing season. Examples include sweet corn rust and downy mildew of cucurbits.

In addition, certain viruses spread by highly motile insects (such as aphids), so rotation does not reduce these diseases either. Since the pathogen does not overwinter locally in the field, survival in residue is not a factor.

Consider all options before making management decisions. Rotation is a good general practice that improves or maintains good soil tilth. Tillage (especially fall tillage) often is not in accord with recommended soil management and conservation practices. If you practice no-till or reduced tillage, you will need to be even more vigilant with other strategies in order to reduce your risk of disease.

Two publications that may be useful for no-till or reduced tillage growers are Building Soils for Better Crops: Sustainable Soil Management and Managing Cover Crops Profitably, both available from the Sustainable Agriculture Research & Education (SARE) Learning Center, [www.sare.org](http://www.sare.org).

## **Water and Humidity Management**

Many bacterial and fungal pathogens thrive in wet conditions. Certain soilborne pathogens such as *Phytophthora* and *Pythium* species are favored by wet soils with poor drainage. Avoid planting into sites with known drainage problems. Improve drainage, and consider using raised beds.

Many leaf spot and fruit rot diseases are favored by high humidity and wet plant surfaces. Using drip irrigation instead of overhead irrigation will reduce leaf wetness. If you use overhead irrigation, irrigate in the morning so that plant surfaces dry before nighttime. Avoid overhead irrigation in the evening.

Reduce plant density to allow better airflow and sunlight to penetrate, which will decrease leaf wetness and humidity. With certain crops (such as tomato) appropriate staking or trellising will also increase airflow. Reducing weed pressure in and along the sides of the crop can also improve airflow. Align rows to maximize airflow and sun exposure.

In greenhouses and high tunnels, use passive ventilation and/or fans to reduce humidity. See Transplant Production (page 23) for details about water and humidity management in that setting. Avoid working wet fields.

## **Scouting and Sanitation**

Depending on the disease and the size of your operation, you can and should rogue out (remove) infected plants. For example, there are no treatments for viral diseases, so you should remove infected plants to reduce the spread to other plants.

Bacterial canker of tomato is another disease where you should rogue out the infected plants and several neighboring plants. Flag the area and come back to check for further spread. Culls should be removed far from the field.

In greenhouse situations, remove the trash frequently, and always keep lids on trash cans to prevent pathogens (and insects) from building up in discarded plant materials. For some crops (such as tomato) stakes and trellises can harbor certain bacteria from one crop to the next. So always use new stakes, or at minimum disinfect them. Disinfect tools frequently, such as at the end of rows. Avoid working fields under wet conditions.

## Other Cultural Practices

Insects (such as thrips, aphids, cucumber beetles, and others) spread numerous diseases, so cultural practices that reduce the insects will reduce the risk of diseases. The comments for the Summary of Cultural Management Strategies for Disease table (page 76) lists some of these practices. See the Insect Management Strategies section (pages 51-60) for guidelines about cultural controls to reduce insects that may spread diseases.

## Chemical Control: Fungicides, Bactericides, Nematicides, Fumigants

Disease control products (fungicides, bactericides, and nematicides) are pesticides. Be sure to read the general section about Pesticide Information and Safety (pages 33-37) for information about safety, equipment, calibration, formulations, storage, and other important topics. For a disease control material to be effective, you must apply an appropriate material at the right time, in the right concentration, and in the right way.

Fungicides can be broadly classified as either contact or systemic. Within those groups, however, there are many active ingredients and multiple modes-of-action. Some fungicides are allowed in organic vegetable production (see page 39), and some are designated as reduced-risk, including certain biopesticides/biological controls (see page 37).

Both contact and systemic fungicides are most effective if you apply them before disease develops. Many diseases are very difficult or impossible to control with chemicals once a severe epidemic is underway. Throughout the crop-specific sections of this book there are details about when you should apply fungicides in order to be most effective (and information about when they may be ineffective).

Pathogens usually require a specific temperature and moisture range in order to cause diseases. For some diseases, knowing those specific requirements can help you time fungicide applications to coincide with disease risk. In some cases, the guidelines are informal, and may simply make you more aware that a wet season may require more applications and a dry season may require fewer. In other cases, the pathogen life cycle is understood well enough that you can use a formal disease forecasting system (see Disease Management with the MELCAST System in the Cucubit Crops section, page 122).

Contact fungicides (also called protectant fungicides) provide a “coat” of protection on the plant’s surface when applied properly. These fungicides are designed to kill fungi on-contact on the surface of plants — hence, the name. Most contact fungicides have multiple modes of action, so fungal pathogens are unlikely to develop resistance to all of these different modes of action at the same time. For this reason, alternating contact fungicides is unnecessary. Good coverage is essential to maximize the efficacy of contact materials.

Systemic fungicides (sometimes called eradicant or curative fungicides) don’t merely coat the surface, they also enter the plant. Once inside the plant, some stay relatively localized. Others move across to the opposite leaf surface, some move upward in the plants, and a few move downward into the roots. They can sometimes eradicate or cure a portion of existing infections. Most systemic fungicides have a single mode of action, so the risk of pathogens developing resistance to these products is greater. The fungicides target a very specific function of the pathogen’s cells, and sometimes the fungus develops methods to evade the activity.

Powdery mildews and downy mildews are particularly prone to resistance development, but there are other examples. The crop sections in this guide flag diseases that are at risk for fungicide resistance. Always read and follow label directions that list how to alternate systemic fungicides and/or combine and rotate with contact fungicides to minimize the resistance development.

Selected Information About Recommended Fungicides (page 79) lists several fungicides and their modes of action to help in resistance management. Each fungicide label is marked with a “FRAC” (Fungicide Resistance Action Committee) code to designate a mode of action group and help growers design a rotation plan.

Bactericides (copper and antibiotic compounds) can help reduce the risk of early-season bacterial disease epidemics, but are most effective when used with other control methods. Copper compounds also are mediocre fungicides and are handled similar to protectant fungicides. Antibiotics serve a similar purpose in certain crops.

Nematicides and fumigants are designed to reduce nematode and soilborne fungus populations before crops are planted. Like other disease-control chemicals, they are most effective when combined with cultural control options such as extended crop rotations and resistant varieties. Nematicides Labeled for Use on Vegetables 2020 (page 60) describes nematode soil treatments.

## Summary of Cultural Management Strategies for Disease

This table describes several diseases listed by crop. This list is not exhaustive, but represents important Midwest diseases. Also listed are the cultural management options available for each disease. The management options are described in more detail in the text. Note that some pathogens have races. The reaction of a particular race of fungus or bacterium will depend on the cultivar or variety grown. Rotation refers to the number of years that the field should be planted to a different crop.

Crop	Disease	Tillage <sup>1</sup>	Seedborne	Rotation <sup>2</sup>	Resistance	Comments
<b>Allium</b> garlic, onion, leek	Alternaria purple blotch, Botrytis leaf blight	3	Yes	3-4	No	Thrips-damaged tissues are more susceptible
	Aster yellows	1	Yes	NE	No	Seed transmission is low, but possible; transmission from garlic bulb/cloves occurs
	Botrytis neck rot	2	No	3	No	Cure bulbs rapidly and properly and avoid injury to neck
	Downy mildew	2	Yes	3	Yes	Resistance in onion only (limited varieties)
	Fusarium basal rot	1	No	4	Yes	
	Smut	1	No	3	No	Transmitted on sets and transplants
	White rot	1	No	NE	No	Do not move <i>Allium</i> spp. into quarantine areas of the U.S. (Columbia Basin)
<b>Asparagus</b>	Cercospora leaf spot and rust	NA	No	NA	Yes	Remove or burn down ferns in the late fall to reduce inoculum
	Fusarium crown and root rot	NA	Yes	NA	Yes	Avoid long harvest periods to maintain vigor
	Phytophthora crown and spear rot	NA	No	NA	No	
<b>Cruciferous vegetables</b>	Alternaria leaf spot	3	Yes	3-4	No	
	Black leg	3	Yes	3-5		Leave 1/4-mile buffer from previously infected fields, delay plant until conditions are dry
	Black rot	3	Yes	2-3	No	
	Club root	NE	No	5 - 7	Yes	Club root pathogen survives on some grass, clover, weedy, and other plants, which influences rotation or cover crop selection
	Downy mildew	3	Yes	2-3	Yes	Resistance in broccoli only
	Fusarium yellows	2	Yes	>6	Yes	
	Powdery mildew	3	No	3	Yes	Resistance for Brussels sprout and cabbage only, avoid over applying nitrogen and drought
	Rhizoctonia diseases	3	No	NE	No	Can form disease complex with black leg pathogen for stem canker
	Sclerotinia stem rot	2	No	NE	No	Very wide host range; rotation for greater than 3 years into grasses, onions, or corn may reduce severe infestations
	White rust	NE	Yes	3	Yes	Remove crop debris from area after harvest

**Summary of Cultural Management Strategies for Disease** (continued)

Crop	Disease	Tillage <sup>1</sup>	Seedborne	Rotation <sup>2</sup>	Resistance	Comments
<b>Cucurbits</b> cantaloupe, cucumber, pumpkin, squash, watermelon	Alternaria leaf blight	3	No	2	No	
	Angular leaf spot	3	Yes	2	Yes	
	Anthracnose	3	Yes	2	No	Race 1 affects mainly cucumber, Race 2 affects mainly watermelon
	Bacterial fruit blotch	3	Yes	2	No	
	Bacterial leaf and fruit spot	3	Yes	3	No	Primarily on pumpkin and winter squash
	Bacterial wilt	1	No	NE	No	Spread by cucumber beetles
	Downy mildew	1	No	NE	Yes	Resistant varieties of cucumber and cantaloupe available
	Fusarium wilt	1	Yes	5-7	Yes	
	Gummy stem blight/black rot	3	Yes	3	No	Also affects pumpkin and watermelon
	Phytophthora blight	2	No	>4	No	Avoid excess water and rotation with solanaceous crops; good drainage is important. Treating seeds with mefenoxam may prevent seedling death.
	Plectosporium blight	3	No	3-4	No	Primarily on pumpkins; manage like black rot
	Powdery mildew	2	No	2	Yes	
<b>Leafy vegetables</b> endive, herbs, lettuce, spinach	Root-knot nematode	2	No	>6	No	Wide host range will affect rotation choices
	Viruses (several)	1	No	NE	No	Spread by aphids; plant crops before insect pressure becomes severe
	Botrytis gray mold	2	No	NE	No	Provide adequate spacing to reduce humidity
	Bottom rot and drop	2	No	NE	No	
	Downy mildew, white rust	NE	Yes	3	Yes	
<b>Legumes</b> cowpea, dry bean, lima bean, pea, snap bean	Lettuce mosaic virus	2	Yes	1	Yes	There are many hosts that may harbor the virus; manage aphid populations
	Powdery mildew	2	No	2	No	
	Anthracnose	3	Yes	3	Yes	Resistance is race-dependent
	Bacterial blights	3	Yes	2	No	
	Rust	1	No	3-4	Yes	
<b>Root crops</b> beet, carrot, parsnip, radish, turnip	Soybean cyst nematode	1	No	1-3	No	Rotation interval depends on the cyst count in soil samples
	White mold and gray mold	2	No	NE	No	
	Aster yellows	2	Yes	NE	No	Seed transmission is low, but possible; destroy perennial weed hosts near high-value crops
	Cercospora leaf spot, Alternaria leaf blight	3	Yes	2	Yes	Resistance availability varies by root crop and pathogen
	Downy mildew, white rust	3	Yes	3	No	Cruciferous weeds and crops are also hosts
	Root-knot nematode	2	No	>6	No	Wide host range affects rotational options
	White mold	2	No	NE	No	Avoid rotation with beans, cucurbits, celery, and cabbage

continued next page

**Summary of Cultural Management Strategies for Disease (continued)**

Crop	Disease	Tillage <sup>1</sup>	Seedborne	Rotation <sup>2</sup>	Resistance	Comments
Sweet corn	Anthracnose	3	No	1-3	Yes	
	Goss' wilt	3	Yes	1	Partial	Control grassy weeds that are hosts
	Leaf blights (southern corn leaf blight, northern corn leaf blight, northern corn leaf spot)	3	No	1	Yes	
	Rust	NE	No	NE	Yes	
	Smut	2	No	NE	Yes	Maintain balanced soil fertility
	Stewart's wilt	1	Yes	NE	Partial	Spreads and survives in flea beetles
Fruiting vegetables eggplant, pepper, tomato	Anthracnose	3	Yes	3-4	No	Stake and mulch
	Bacterial canker	3	Yes	3-4	No	Disease is systemic
	Bacterial speck	3	Yes	2	Yes	Some strains are copper resistant
	Bacterial spot	3	Yes	2-3	Yes <sup>3</sup>	Copper resistance reported — check with your state pathologist
	Early blight	3	Yes	3-4	Partial	Some resistance to stem canker
	Fusarium crown and root rot	2	Yes	>6	Yes	Graft to resistant root stocks; use resistant varieties
	Late blight	1	No	NE	No	Does not overwinter in the Midwest
	Leaf mold	2	Yes	2	Yes	Notably a problem in high tunnels and greenhouses; infected transplants will experience disease outdoors
	Powdery mildew	2	No	2	No	
	Root-knot nematode	2	No	>6	Yes	Wide host range
	Septoria leaf spot	3	No	2-3	No	
	Southern blight	3	No	>6	No	Favored by high temperatures
	Tobacco mosaic virus	1	No	2	Yes	Spread by contact
	Tomato spotted wilt virus	1	No	NE	Yes	Spread by thrips
	Verticillium	2	No	>6	Yes	
	White mold	2	No	5-6	No	Wide host range; rotate with grasses; flood for 23-45 days
All vegetables	Damping-off	1	No	NE	No	Avoid excess moisture, sanitize seedling trays

<sup>1</sup>1=tillage has limited effect, 2=tillage is of limited help, 3=tillage is an important control<sup>2</sup>Numbers refer to the number of years that the field should be planted to a different crop. NE=not effective.<sup>3</sup>Pepper only

## Selected Information About Recommended Fungicides

This table includes selected information about the fungicides recommended in this guide. The products are listed alphabetically by the **Trade Name**. The table also lists the **Common Name** of active ingredient.

The **Signal Word** column indicates the product's possible toxicity. If the signal word is set in bold, the product is a restricted use product (RUP). See page 33.

The **FRAC Code** column indicates the product's mode of action. FRAC stands for Fungicide Resistance Action Committee. Refer to product labels for information about alternating fungicide modes of action.

The **Greenhouse Use** column has one of three listings:

*yes*=the product label explicitly allows greenhouse use

*no*=the product label explicitly prohibits greenhouse use

*silent*=the product label does not mention greenhouse use — states vary about whether such products are allowed in greenhouse production

The **OMRI** column, products marked with an X are listed by the Organic Material Review Institute (omri.org) and may be suitable for organic production. Check with your certifier. See page 39 for more information.

Trade Name	Common Name	Signal Word	FRAC Code	Greenhouse Use	OMRI
Actigard®	acibenzolar-s-methyl	Caution	21	silent	
Actinovate AG*	<i>Streptomyces lydicus</i> WYEC 108	Caution	48	yes	X
Aframe*	azoxystrobin	Caution	11	no	
Agri-Fos*	phosphorous acid	Caution	33	silent	
Agri-mycin 17*	streptomycin sulfate	Caution	25	yes	
Aliette WDG*	fosetyl-aluminum	Caution	33	silent	
Allegiance-FL*	metalaxyl	Caution	4	certain crops, see label	
Aproach*	picoxystrobin	Caution	11	silent	
Apron XL*	mefenoxam	Warning	4	certain crops, see label	
Aprovia Top*	difenoconazole + benzovindiflupyr	Warning	3 + 7	no	
Ariston*	chlorothalonil + cymoxanil	Caution	M5 + 27	no	
Badge SC*	copper hydroxide + copper oxychloride	Danger	M1	yes	
Basic Copper 53*	copper sulfate	Warning	M1	no	X
Blocker 4F*	pentachloronitrobenzene (PCNB)	Caution	14	silent	
Botran 75W*	dichloro-nitroaniline	Caution	14	certain crops, see label	
Bravo Ultrex*	chlorothalonil	Danger	M5	no	
Bravo Weather Stik*	chlorothalonil	Caution	M5	no	
C-O-C-S WDG*	copper oxychloride + copper sulfate	Warning	M1	yes	
Cabrio EG*	pyraclostrobin	Caution	11	no	
Cannonball WG*	fludioxinil	Caution	12	silent	
Catamaran*	potassium phosphite + chlorothalonil	Caution	33 + M5	silent	
Cercobin*	thiophanate-methyl	Caution	1	silent	
Champ DP*	copper hydroxide	Warning	M1	certain crops, see label	
Champ Formula 2F*	copper hydroxide	Warning	M1	silent	
Champ WG*	copper hydroxide	Danger	M1	Silent	X
ChampION++*	copper hydroxide	Caution	M1	certain crops, see label	X
Contans*	<i>Coniothyrium minitans</i>	Caution	-	yes	X
Copper Count N*	copper ammonium carbonate	Caution	M1	yes	
Cuprofix Ultra Disperss*	copper sulfate	Caution	M1	yes	

*continued next page*

**Selected Information About Recommended Fungicides (continued)**

Trade Name	Common Name	Signal Word	FRAC Code	Greenhouse Use	OMRI
Curzate 60DF*	cymoxanil	Warning	27	silent	
Custodia*	azoxystrobin + tebuconazole	Warning	11 + 3	no	
Dithane F45 Rainshield*	mancozeb	—	M3	silent	
Dithane M45*	mancozeb	Caution	M3	yes	
Echo 720*	chlorothalonil	Warning	M5	no	
Echo 90DF*	chlorothalonil	Danger	M5	no	
Echo ZN*	chlorothalonil	Warning	M5	no	
Elatus*	azoxystrobin + benzovindiflupyr	Caution	11 + 7	certain crops, see label	
Elixir*	chlorothalonil + mancozeb	Caution	M5 + M3	silent	
Elumin®	ethaboxam	Caution	22	no	
Endura*	boscalid	Warning	7	no	
Evito 480SC*	fluoxastrobin	Caution	11	silent	
Flint 50WG*	trifloxystrobin	Caution	11	no	
Fontelis*	penthiopyrad	Caution	7	certain crops, see label	
Forum*	dimethomorph	Caution	40	no	
Fosphite*	phosphorous acid	Caution	33	yes	
Gavel 75DF*	zoxamide + mancozeb	Caution	22 + M3	silent	
Gem 500*	trifloxystrobin	Caution	11	silent	
Headline AMP*	metconazole + pyraclostrobin	Warning	3 + 11	no	
Headline EC*	pyraclostrobin	Warning	11	no	
Headline SC*	pyraclostrobin	Warning	11	no	
Heritage*	azoxystrobin	Caution	11	silent	
Initiate 720*	chlorothalonil	Caution	M5	no	
Inspire Super*	difenoconazole + cyprodinil	Caution	3 + 9	certain crops, see label	
Iprodione 4L AG*	iprodione	Caution	2	silent	
Kenja 400SC*	isofetamid	Caution	7	silent	
Kentan DF*	copper hydroxide	Danger	M1	yes	
Kocide 2000*	copper hydroxide	Warning	M1	yes	
Kocide 3000*	copper hydroxide	Caution	M1	yes	
Koverall 75WP*	mancozeb	Caution	M3	yes	
Kumulus DF*	sulfur	Caution	M2	silent	X
Luna Experience*	fluopyram + tebuconazole	Caution	7 + 3	silent	
Luna Sensation*	fluopyram + trifloxystrobin	Caution	7 + 11	silent	
Luna Tranquility*	fluopyram + pyrimethanil	Caution	7 + 9	certain crops, see label	
ManKocide*	copper hydroxide + mancozeb	Danger	M1 + M3	silent	
Manzate Max*	mancozeb	Caution	M3	silent	
Maxim 4FS*	fludioxonil	Caution	12	silent	
Maxim MZ 0.5D*	mancozeb + fludioxonil	Caution	M3 + 12	silent	
Maxim XL*	fludioxonil + mefenoxam	Caution	12 + 4	NA	
Merivon*	fluxapyroxad + pyraclostrobin	Warning	7 + 11	no	
Mertect 340F*	thiabendazole	Caution	1	no	
Meteor*	iprodione	Caution	2	silent	
Micro Sulf	sulfur	Caution	M2	silent	
Microthiol Disperss*	sulfur	Caution	M2	silent	X
Moncoat MZ*	mancozeb + flutolanil	Caution	M3 + 7	NA	

**Selected Information About Recommended Fungicides (continued)**

Trade Name	Common Name	Signal Word	FRAC Code	Greenhouse Use	OMRI
Moncut <sup>*</sup>	flutolanil	Caution	7	silent	
Monsoon <sup>*</sup>	tebuconazole	Caution	3	silent	
Muscle ADV <sup>*</sup>	chlorothalonil + tebuconazol	Caution	M5 + 3	no	
Nevado 4F <sup>*</sup>	iprodione	Caution	2	silent	
Nu-Cop 3L <sup>*</sup>	copper hydroxide	Danger	M1	silent	
Nu-Cop 50DF <sup>*</sup>	copper hydroxide	Danger	M1	certain crops, see label	X
Omega 500F <sup>*</sup>	fluazinam	Warning	29	silent	
Orius 3.6F <sup>*</sup>	tebuconazole	Caution	3	silent	
Orondis Opti A <sup>*</sup>	oxathiapiprolin	Caution	49	silent	
Orondis Opti B <sup>*</sup>	chlorothalonil	Caution	M5	no	
Orondis Opti <sup>*</sup>	oxathiapiprolin + chlorothalonil	Danger	49 + M5	no	
Orondis Ultra A <sup>*</sup>	oxathiapiprolin	Caution	49	certain crops, see label	
Orondis Ultra B <sup>*</sup>	mandipropamid	—	3	certain crops, see label	
Penncozeb 75DF <sup>*</sup>	mancozeb	Caution	M3	silent	
Phostrol <sup>*</sup>	phosphorous acid	Caution	33	silent	
Presidio <sup>*</sup>	fluopicolide	Caution	43	no	
Previcur Flex <sup>*</sup>	propamocarb	Caution	28	certain crops, see label	
Priaxor <sup>*</sup>	fluxapyroxad + pyraclostrobin	Caution	7 + 11	no	
Pristine <sup>*</sup>	boscalid + pyraclostrobin	Caution	7 + 11	no	
Procure 480SC <sup>*</sup>	triflumizole	Caution	3	silent	
Proline 480SC <sup>*</sup>	prothioconazole	Caution	3	no	
ProPhyt <sup>*</sup>	phosphorous acid	Caution	33	silent	
Propimax EC <sup>*</sup>	propiconazole	Warning	3	no	
Quadris Opti <sup>*</sup>	azoxystrobin + chlorothalonil	Warning	11 + M5	no	
Quadris Ridomil Gold <sup>*</sup>	metalaxyl + azoxystrobin	Caution	4 + 11	silent	
Quadris Top <sup>*</sup>	azoxystrobin + difenoconazole	Caution	11 + 3	silent	
Quadris <sup>*</sup>	azoxystrobin	Caution	11	no	
Quilt Xcel <sup>*</sup>	azoxystrobin + propiconazole	Caution	3 + 11	no	
Quilt <sup>*</sup>	azoxystrobin + propiconazole	Warning	3 + 11	no	
Quintec <sup>*</sup>	quinoxyfen	Caution	13	silent	
Rally 40WSP <sup>*</sup>	myclobutanil	Caution	3	no	
Ranman SC <sup>*</sup>	cyazofamid	Caution	21	certain crops, see label	
Reason 500SC <sup>*</sup>	fenamidone	Caution	11	no	
Regalia <sup>*</sup>	<i>Reynoutria sachalinensis</i>	Caution	P5	silent	X
Revus Top <sup>*</sup>	mandipropamid + difenoconazole	Caution	3 + 40	silent	
Revus <sup>*</sup>	mandipropamid	—	40	silent	
Rhyme <sup>*</sup>	flutriafol	Warning	3	silent	
Ridomil Gold GR <sup>*</sup>	mefenoxam	Caution	4	no	
Ridomil Gold MZ <sup>*</sup>	mefenoxam + mancozeb	Caution	4 + M3	silent	
Ridomil Gold SL <sup>*</sup>	mefenoxam	Caution	4	no	
Ridomil Gold/Bravo <sup>*</sup>	mefenoxam + chlorothalonil	Warning	4 + M5	no	
Ridomil Gold/Copper <sup>*</sup>	mefenoxam + copper hydroxide	Danger	4 + M1	no	
Rovral 4F <sup>*</sup>	iprodione	Caution	2	silent	

continued next page

**Selected Information About Recommended Fungicides** (continued)

Trade Name	Common Name	Signal Word	FRAC Code	Greenhouse Use	OMRI
Satori <sup>*</sup>	azoxystrobin	Caution	11	no	
Scala SC <sup>*</sup>	pyrimethanil	Caution	9	certain crops, see label	
Sectagon 42 <sup>*</sup>	metam sodium	<b>Danger</b>	-	no	
Sectagon K54 <sup>*</sup>	metam potassium	<b>Danger</b>	-	no	
Serenade Opti <sup>*</sup>	<i>Bacillus subtilis</i>	Caution	44	yes	X
Stratego <sup>*</sup>	propiconazole + trifloxystrobin	Warning	3 + 11	silent	
Sulfur DF <sup>*</sup>	sulfur	Caution	M2	silent	X
Switch 62.5WG <sup>*</sup>	cyprodinil + fludioxonil	Caution	9 + 12	silent	
Tanos <sup>*</sup>	famoxadone + cymoxanil	Caution	11 + 27	silent	
Tebuzol 3.6F <sup>*</sup>	tebuconazole	Caution	3	silent	
Telone C-35 <sup>*</sup>	1,3-dichloropropene + chloropicrin	<b>Danger</b>	- + 8B (IRAC)	no	
Thiolux <sup>*</sup>	sulfur	Caution	M2	silent	X
Tilt <sup>*</sup>	propiconazole	Warning	3	no	
Toledo <sup>*</sup>	tebuconazole	Caution	3	silent	
Topguard EQ <sup>*</sup>	azoxystrobin + flutriafol	Caution	11 + 3	silent	
Topsin 4.5FL <sup>*</sup>	thiophanate-methyl	Caution	1	silent	
Topsin M WSB <sup>*</sup>	thiophanate-methyl	Caution	1	silent	
Torino <sup>*</sup>	cyflufenamid	Caution	U6	silent	
Ultra Flourish <sup>*</sup>	mefenoxam	Warning	4	no	
Unicorn DF <sup>*</sup>	sulfur + tebuconazole	Caution	M2 + 3	silent	
Uniform <sup>*</sup>	azoxystrobin + mefenoxam	Caution	11 + 4	silent	
Vanguard WG <sup>*</sup>	cyprodinil	Caution	9	silent	
Velum Prime <sup>*</sup>	fluopyram	Caution	7	silent	
Viathon <sup>*</sup>	potassium phosphite + tebuconazole	Caution	33 + 3	silent	
Vibe <sup>*</sup>	tebuconazole	Caution	3	silent	
Vivando <sup>*</sup>	metrofenone	Caution	U8	silent	
Zampro <sup>*</sup>	ametoctradin + dimethomorph	Caution	45 + 40	no	
Zing! <sup>®</sup>	zoxamide + chlorothalonil	Caution	22 + M5	no	
Ziram 76DF <sup>*</sup>	ziram	<b>Danger</b>	M3	silent	

## Preharvest Intervals (Days) and Re-Entry Intervals for Fungicides Registered for Use on Midwest Vegetables in 2020<sup>a</sup>

	Actigard <sup>®</sup>	Agri-Fos <sup>®</sup> , Fosphite <sup>®</sup> , ProPhyte <sup>®</sup>	Approach <sup>®</sup>	Bravo <sup>®</sup> , Echo <sup>®</sup> , Equus 720 <sup>®</sup>	Cabrio <sup>®</sup>	Dithane <sup>®</sup> , Manzate <sup>®</sup> , Penncozeb <sup>®</sup>	Endura <sup>®</sup>	fixed copper	Flint <sup>®</sup>	Fontelis <sup>®</sup>	Forum <sup>®</sup>	Inspire Super <sup>®</sup>	Kumulus <sup>®</sup>	Merivon <sup>®</sup>	Monsoon <sup>®</sup> , Onset <sup>®</sup> , Toledo <sup>®</sup>	Presidio <sup>®</sup>	Previcur Flex <sup>®</sup>	Pristine <sup>®</sup>	Procure <sup>®</sup>	Propimax <sup>®</sup> , Tilt <sup>®</sup>	Quadris <sup>®</sup> , Satori <sup>®</sup>	Quadris Top <sup>®</sup>	Quintec <sup>®</sup>	Rally <sup>®</sup>	Ranman <sup>®</sup>	Revus <sup>®</sup>	Revus Top <sup>®</sup>	Rovral <sup>®</sup>	Switch <sup>®</sup>	Tanos <sup>®</sup>	Topsin M <sup>®</sup>	Torino <sup>®</sup>	Zampro <sup>®</sup>		
Asparagus	b	190	180		180				0	180								100	14																
Bean, Dry	0	14	14		21	0	b		0	0	14						7c	14							d	7	28								
Bean, Green	0	14	7		7	0	0		0	0	7					7c	0		0	0	1	d	7	14											
Beet	0		0		0	7	0		0	7	7	7				14c	0								7										
Broccoli	7	0	7	0	7b	0	0		0	0	7	0	7	2		1	0	1			0	1	0	7			0								
Brussels Sprouts	7	0	7	0		0	0		0	0	7	0	2		1	0	1		0	1		0	1	7			0								
Cabbage	7	0	7	0	7b	0	0		0	0	7	0	7	2		1	0	1		0	1		0	1	7			0							
Cabbage, Chinese	7	0	7	0	b	0	0		0	0	7		7	2		1	0	1		0	1		0	1	7			0							
Cantaloupe	0	0	0	0	5	0	0	0	1	0	7	0	0	7	2	2	0	0	1	1	3	0	0	0		1	3	1	0	0					
Carrot	0	0	0	0	0	0	7	0		0	7	7	0	14	0	7		14		0	7		14		0	7									
Cauliflower	7	0	7	0		0	0		0	0	7	0		2			0			0	1		7			0									
Celery	0	7	0	0	0	7	3	0		0	1	2	0	14	0					1	0	0	0	0	0	0	0	0	0	0					
Collard	7	0		3	14	0		0	0	7	0	7	2		1	0	1		0	1		0	1	7			0								
Cucumber	0	0	0	0	5	0	0	0	1	0	7	0	0	7	2	2	0	0	1	1	0	0	0	1	3	1	0	0							
Eggplant	0	3	0	0	0	3	0	0	0	0	0		2			0	0	0	0	0	1	0	0	0	0	4									
Endive	0	0	0	14	0	3	0		1	2		0	0		0		0		0	1	0	1	0	1	0										
Kale	7	0		3	14	0		0	0	7	0	7	2		1	0	1		0	1		0	1	7			0								
Lettuce, Head	7	0	0	b	14	0		3	0	0	1	2	2	0	0	0	1	3	0	1	14	0	1	0	0	0	0	0	0	0					
Lettuce, Leaf	7	0	0	b	14	0		3	0	0	1	2	2	0	0	0	1	3	0	1	14	0	1	0	0	0	0	0	0	0					
Mint	0	80							0						b	b		30																	
Mustard	7	0		3	14	0		0	0	7		7	2		1	0	1		0	1		0	1	7			0								
Onion, Bulb	7	0	7	7	7	7	0		3	0	7	0	7	7		7	14	0	7		7	7	7	3	b	0									
Onion, Green	0	14	7	7	0		3	0	14	0	7	7		7	0	0	7		7	7	7	3	0	0											
Parsley	0	0	0	0	0	0	7	3	0		1	2		0	14c	0		0	1		0	1	0	1	0	1	0								
Parsnip	0	10	0	14		b	0	0		0		7	7		0		0					7													
Peas	0	14			b	0	0		0						0																				
Pepper	14e	0	3	0	7	0	0	3	0	0	0	0	2	5		0	0	3	0	0	1	0	3	4											
Potato	0	7	b	10	0		4	0			14				14	14		7	14	14		7	14	14	21	4									
Pumpkin	0	0	0	5b	0	0	0	1	0	7	0	0	7	2	2	0	0	1	1	3	0	0	0	1	3	1	0	0							
Radish	0	0	0	0	7	0			7	0		7	7		0					7			7												
Spinach	7	0	0	0	0	3	0		1	2				0		0	1	0	1	0	1	0	1	0	1	0	0	0							
Squash, Summer	0	0	0	0	5	0	0	0	1	0	7	0	0	7	2	2	0	0	1	1	0	0	0	0	1	3	1	0	0						
Squash, Winter	0	0	0	0	5b	0	0	0	1	0	7	0	0	7	2	2	0	0	1	1	3	0	0	0	1	3	1	0	0						
Sweet Corn	0f	7	14	7	0					7				14																					
Tomato	14	0	0	0	5	0	0	3	0	4	0	0	2	5		0	0	0	0	0	1	0	3	4											
Turnip	0	0	0	0	0	7	0	b	b	0	7	7	7	b	0	b	b	0	b	7			7												
Watermelon	0	0	0	0	5	0	0	0	1	0	7	0	0	7	2	2	0	0	1	1	3	0	0	0	1	3	1	0	0						
Re-Entry Interval (hr)	12	4	12	12	12	24	12	48	12	12	12	12	24	12	12	12	12	12	12	4	12	12	24	12	4	12	12	12	b	4	12				

<sup>a</sup>Check label directions before applying any of these pesticides.

<sup>b</sup>See label.

<sup>c</sup>Do not use Propimax<sup>®</sup>.

<sup>d</sup>Do not apply past peak bloom.

<sup>e</sup>Chile only.

<sup>f</sup>Do not use ProPhyte<sup>®</sup>.

## Disease Forecasting Systems

There are two types of forecasting systems. The first type tracks a disease epidemic and forecasts where the disease might show up next. The second type is based on weather.

Weather-based disease forecasting systems are based on the requirements for a particular disease or set of diseases. Each foliar disease requires the right combination of temperature and leaf wetness for infection to occur and the disease to spread. Disease forecasting systems predict the likely severity of a disease based on recent weather data. Successful weather-based disease-forecasting systems take the guessing out of fungicide application schedules.

In general, weather-based disease-forecasting systems will advise growers to apply fungicides more frequently during wet weather and allow growers to cut back on fungicide applications during drier weather. Two of these systems are briefly described below: MELCAST and TOM-CAST.

MELCAST is a weather-based disease-forecasting system for Alternaria leaf blight, anthracnose and gummy stem blight of cantaloupe and watermelon. The MELCAST system was developed by Rick Latin at Purdue University. Growers can learn more about MELCAST from these Purdue Extension publications: BP-67-W, *Foliar Disease Control Using MELCAST* and BP-64-W, *MELCAST: Melon Disease Forecaster* (both available from the Purdue Extension Education Store, [www.edustore.purdue.edu](http://www.edustore.purdue.edu)).

MELCAST is available for selected sites in some of the states covered by this guide. In season, growers can obtain MELCAST values at [MELCAST.info](http://MELCAST.info) or 800-939-1604. Interested growers can contact Dan Egel at 812-886-0198 or [egel@purdue.edu](mailto:egel@purdue.edu).

TOM-CAST, hosted by Cornell University, was originally developed to help manage fungal foliar diseases of tomatoes. More recently, Michigan State University researchers have validated this system for use at with asparagus and carrot.



Slugs and snails prefer moist soils and plenty of organic matter.

To manage purple spot of asparagus and Alternaria and Cercospora foliar blights of carrot, use the TOM-CAST system with 15 disease severity values (DSVs) to schedule sprays instead of a calendar-based program. For best results use a tolerant or resistant cultivar in combination with the TOM-CAST System. TOM-CAST is available for selected sites for some states at [newa.cornell.edu/index.php?page=tomato-diseases-tomcast](http://newa.cornell.edu/index.php?page=tomato-diseases-tomcast).

For TOM-CAST reports in West-Central Michigan asparagus and carrot fields, contact Ben Werling at 231-873-2129 or [werlingb@msu.edu](mailto:werlingb@msu.edu).

Forecasting systems that are based on tracking a disease epidemic usually map a particular disease online. For example, The Cucurbit Downy Mildew Forecast site tracker is available at [cdm.ipmpipe.org](http://cdm.ipmpipe.org). And USAblight tracks late blight of tomato and potato at [usabligh.org](http://usabligh.org).

For more information about either system, contact the vegetable disease specialist in your state.

## Slug and Snail Control

Occasionally, slugs and snails seriously damage seedlings; tender, low-growing leafy vegetables; or ripening fruit that are on the ground. Slug and snail feeding damage (hollowed-out areas) can be found anywhere on fruit, but is usually concentrated near the stem. Slugs leave behind telltale slime trails (silvery trails) on the surfaces of fruit or leaves. Slugs and snails are active at night or cloudy days.

Slugs and snails favor continuously moist soil and organic mulch. They lay eggs in groups in moist soil, and overwinter in organic mulch. Slugs can complete their entire life cycle in a field.

If slugs are a problem, their hiding places (i.e., boards, stones, weedy areas), should be eliminated. Heavy mulching creates favorable slug habitats, so should be thinned so the soil can become warm and dry. Raised beds that can dry out more readily than flat beds reduce slug problems. Using black plastic mulch discourages slug build-up because it causes the soil to heat up and dry out.

As a last resort, metaldehyde bait (e.g., Clean Crop, 3.5G® at 30-40 lbs./A or Clean Crop 7.5G® at 15-20 lbs./A) can be used and is usually very effective. Follow label instructions carefully for application methods for each particular vegetable crop. Apply bait in evening after a rain or irrigation. An organic alternative to metaldehyde is iron phosphate. Baits containing iron phosphate are sold under the trade name Sluggo® (and others) and are only slightly less effective than metaldehyde baits.

## Common and Scientific Vegetable Pest Names

The names in this table represent the common and scientific (Latin) names of all the pests represented in this guide. The names are provided to help users interpret information presented in pesticide labels and other sources.

Insects		
Common Name	Scientific Name	Order
armyworm	<i>Mythimna (Pseudaletia) unipuncta</i>	Lepidoptera
asparagus aphid	<i>Brachycorynella asparagi</i>	Hemiptera
asparagus beetle	<i>Crioceris asparagi</i>	Coleoptera
asparagus miner	<i>Ophiomyia simplex</i>	Diptera
aster leafhopper	<i>Macrosteles quadrilineatus</i>	Hemiptera
bandedwinged whitefly	<i>Trialeurodes abutiloneus</i>	Hemiptera
bean aphid	<i>Aphis fabae</i>	Hemiptera
bean leaf beetle	<i>Cerotoma trifurcata</i>	Coleoptera
bean seed maggot	<i>Delia florilega</i>	Diptera
beet armyworm	<i>Spodoptera exigua</i>	Lepidoptera
black cutworm	<i>Agrotis ipsilon</i>	Lepidoptera
brown marmorated stink bug	<i>Halymorpha halys</i>	Hemiptera
brown stink bug	<i>Euschistus servus</i>	Hemiptera
cabbage aphid	<i>Brevicoryne brassicae</i>	Hemiptera
cabbage looper	<i>Trichoplusia ni</i>	Lepidoptera
cabbage maggot	<i>Delia radicum</i>	Diptera
carrot weevil	<i>Listronotus oregonensis</i>	Coleoptera
celery leafhopper	<i>Udea rubigalis</i>	Lepidoptera
Colorado potato beetle	<i>Leptinotarsa decemlineata</i>	Coleoptera
corn earworm	<i>Helicoverpa zea</i>	Lepidoptera
bollworm		
tomato fruitworm		
corn flea beetle	<i>Chaetocnema pulicaria</i>	Coleoptera
corn leaf aphid	<i>Rhopalosiphum maidis</i>	Hemiptera
cross-striped cabbageworm	<i>Evergestis rimosalis</i>	Lepidoptera
crucifer flea beetle	<i>Phyllotreta cruciferae</i>	Coleoptera
diamondback moth	<i>Plutella xylostella</i>	Lepidoptera
eastern field wireworm	<i>Limonius agonus</i>	Coleoptera
eggplant flea beetle	<i>Epitrix fuscula</i>	Coleoptera
European corn borer	<i>Ostrinia nubilalis</i>	Lepidoptera
fall armyworm	<i>Spodoptera frugiperda</i>	Lepidoptera
flower thrips	<i>Frankliniella tritici</i>	Thysanoptera
garden webworm	<i>Achyra rantalis</i>	Lepidoptera
golden tortoise beetle	<i>Charidotella (Metriona) sexpunctata bicolor</i>	Coleoptera
green cloverworm	<i>Hypena (Plathypena) scabra</i>	Lepidoptera
green peach aphid	<i>Myzus persicae</i>	Hemiptera
green stink bug	<i>Acrosternum hilare</i>	Hemiptera
harlequin bug	<i>Murgantia histrionica</i>	Hemiptera
horseradish flea beetle	<i>Phyllotreta armoraciae</i>	Coleoptera
imported cabbageworm	<i>Pieris rapae</i>	Lepidoptera
melon aphid/cotton aphid	<i>Aphis gossypii</i>	Hemiptera
Mexican bean beetle	<i>Epilachna varivestis</i>	Coleoptera
northern corn rootworm	<i>Diabrotica barberi</i>	Coleoptera
onespotted stink bug	<i>Euschistus variolarius</i>	Hemiptera
onion maggot	<i>Delia antiqua</i>	Diptera
onion thrips	<i>Thrips tabaci</i>	Thysanoptera
palestriped flea beetle	<i>Systena blanda</i>	Coleoptera
pea aphid	<i>Acyrthosiphon pisum</i>	Hemiptera
potato aphid	<i>Macrosiphum euphorbiae</i>	Hemiptera
potato flea beetle	<i>Epitrix cucumeris</i>	Coleoptera
potato leafhopper	<i>Empoasca fabae</i>	Hemiptera

Insects		
Common Name	Scientific Name	Order
purplebacked cabbageworm	<i>Evergestis pallidata</i>	Lepidoptera
rhubarb curculio	<i>Lixus concavus</i>	Coleoptera
saltmarsh caterpillar	<i>Estigmene acrea</i>	Lepidoptera
seedcorn maggot	<i>Delia platura</i>	Diptera
serpentine leafminer	<i>Liriomyza brassicae</i>	Diptera
soybean thrips	<i>Neohydatothrips variabilis</i>	Thysanoptera
spinach flea beetle	<i>Disonycha xanthomelas</i>	Coleoptera
spinach leafminer	<i>Pegomya hyoscyami</i>	Diptera
spotted asparagus beetle	<i>Crioceris duodecimpunctata</i>	Coleoptera
spotted cucumber beetle	<i>Diabrotica undecimpunctata howardi</i>	Coleoptera
southern corn rootworm		
squash bug	<i>Anasa tristis</i>	Hemiptera
squash vine borer	<i>Melittia cucurbitae</i>	Lepidoptera
stalk borer	<i>Papaipema nebris</i>	Lepidoptera
striped cucumber beetle	<i>Acalymma vittatum</i>	Coleoptera
striped flea beetle	<i>Phyllotreta striolata</i>	Coleoptera
sugarbeet wireworm	<i>Limonius californicus</i>	Coleoptera
sweetpotato flea beetle	<i>Chaetocnema confinis</i>	Coleoptera
sweetpotato weevil	<i>Cylas formicarius elegantulus</i>	Coleoptera
tarnished plant bug	<i>Lygus lineolaris</i>	Hemiptera
tobacco hornworm	<i>Manduca sexta</i>	Lepidoptera
tomato hornworm	<i>Manduca quinquemaculata</i>	Lepidoptera
turnip aphid	<i>Lipaphis pseudobrassicae</i>	Hemiptera
twospotted spider mite	<i>Tetranychus urticae</i>	Acari
variegated cutworm	<i>Peridroma saucia</i>	Lepidoptera
vegetable leafminer	<i>Liriomyza sativae</i>	Diptera
western bean cutworm	<i>Striacosta (Loxagrotis) albicosta</i>	Lepidoptera
western corn rootworm	<i>Diabrotica virgifera virgifera</i>	Coleoptera
yellow woollybear	<i>Spilosoma virginica</i>	Lepidoptera
zebra caterpillar	<i>Melanchra picta</i>	Lepidoptera
Weeds		
Common Name	Scientific Name	Family
barnyardgrass	<i>Echinochloa crus-galli</i>	Poaceae
black nightshade	<i>Solanum nigrum</i>	Solanaceae
common lambsquarters	<i>Chenopodium album</i>	Chenopodiaceae
common purslane	<i>Portulaca oleracea</i>	Portulacaceae
common ragweed	<i>Ambrosia artemisiifolia</i>	Asteraceae
common waterhemp	<i>Amaranthus rudis</i>	Amaranthaceae
crabgrass	<i>Digiteria sanguinalis</i>	Poaceae
eastern black nightshade	<i>Solanum ptycanthum</i>	Solanaceae
entireleaf morningglory	<i>Ipomoea hederacea</i>	Convolvulaceae
fall panicum	<i>Panicum dichotomiflorum</i>	Poaceae
giant foxtail	<i>Setaria faberii</i>	Poaceae
giant ragweed	<i>Ambrosia trifida L.</i>	Asteraceae
goosegrass	<i>Eleusine indica</i>	Poaceae
green foxtail	<i>Setaria viridis</i>	Poaceae
hairy galinsoga	<i>Galinsoga quadriradiata</i>	Asteraceae
ivyleaf morningglory	<i>Ipomoea hederacea</i>	Convolvulaceae
jimsonweed	<i>Datura stramonium</i>	Solanaceae

Weeds		
Common Name	Scientific Name	Family
ladysthumb	<i>Polygonum persicaria</i>	Polygonaceae
Pennsylvania smartweed	<i>Polygonum pensylvanicum</i>	Polygonaceae
redroot pigweed	<i>Amaranthus retroflexus</i>	Amaranthaceae
smooth pigweed	<i>Amaranthus hybridus</i>	Amaranthaceae
tall morningglory	<i>Ipomoea purpurea</i>	Convolvulaceae
velvetleaf	<i>Abutilon theophrasti</i>	Malvaceae
yellow foxtail	<i>Setaria pumila</i>	Poaceae
yellow nutsedge	<i>Cyperus esculentus</i>	Cyperaceae
Diseases		
Disease	Pathogen	Host Crop
Alternaria leaf blight of cucurbits	<i>Alternaria cucumerina</i>	cucurbits
Alternaria leaf spot of beet	<i>Alternaria alternata, A. brassicae</i>	beet
Alternaria leaf spot of carrots	<i>Alternaria dauci</i>	carrot
Alternaria leaf spot of cole crops	<i>Alternaria brassicae</i>	cole crops
Alternaria leaf spot of parsnip, turnip	<i>Alternaria</i> spp.	parsnip, turnip
Alternaria leaf spot of radish	<i>Alternaria raphanin</i>	radish
angular leaf spot	<i>Pseudomonas syringae</i> pv. <i>lachrymans</i>	cucurbits
anthracnose of cucurbits	<i>Colletotrichum orbiculare</i>	cucurbits
Anthracnose of celery	<i>Colletotrichum acutatum</i>	celery
Anthracnose of corn	<i>Colletotrichum graminicola</i>	sweet corn
Anthracnose of legumes	<i>Colletotrichum lindemuthiana</i>	Legumes
Anthracnose of pepper/tomato	<i>Colletotrichum</i> spp.	pepper, tomato
Ascochyta leaf spot	<i>Ascochyta rhei</i>	rhubarb
aster yellows of carrot, parsnip	<i>Phytoplasma</i> sp.	carrot, parsnip
aster yellows of potato	<i>Phytoplasma</i> spp.	potato
bacterial canker	<i>Clavibacter michiganensis</i> subsp. <i>michiganensis</i>	tomato
bacterial flower stalk and leaf necrosis	<i>Pantoea agglomerans</i>	onion
bacterial fruit blotch	<i>Acidovorax citrulli</i>	cucurbits
bacterial leaf blight of carrot	<i>Xanthomonas campestris</i> pv. <i>carotae</i>	carrot
bacterial leaf blight of celery	<i>Pseudomonas syringae</i> pv. <i>apii</i>	celery
bacterial leaf blight of onion	<i>Xanthomonas axonopodis</i> pv. <i>allii</i>	onion
bacterial leaf and fruit spot	<i>Xanthomonas cucurbitae</i>	cucurbits
bacterial speck	<i>Pseudomonas syringae</i> pv. <i>tomato</i>	tomato
bacterial spot	<i>Xanthomonas campestris</i> pv. <i>vesicatoria</i>	pepper, tomato
bacterial wilt	<i>Erwinia tracheiphila</i>	cucurbits
basal rot of garlic, onion	<i>Fusarium culmorum</i>	garlic, onion
bean yellow mosaic	<i>Bean yellow mosaic virus</i>	legumes
black dot	<i>Colletotrichum coccodes</i>	potato

Diseases		
Disease	Pathogen	Host Crop
black leg of cole crops	<i>Phoma lingam</i>	cole crops
black rot of sweet potato	<i>Ceratocystis fimbriata</i>	sweet potato
black rot of cole crops	<i>Xanthomonas campestris</i> pv. <i>campestris</i>	cole crops
blackleg	<i>Erwinia carotovora</i> subsp. <i>atroseptica</i>	potato
Botrytis leaf blight	<i>Botrytis squamosa</i>	onion
Botrytis neck rot	<i>Botrytis allii</i>	onion
Botrytis gray mold	<i>Botrytis cinerea</i>	lettuce, spinach, tomato, legumes
bottom rot/damping-off	<i>Rhizoctonia solani</i>	lettuce
buckeye rot	<i>Phytophthora</i> spp.	tomato
canker/black scurf	<i>Rhizoctonia solani</i>	potato
cavity spot	<i>Pythium violae, Pythium</i> spp.	carrot
Cercospora leaf spot of beet	<i>Cercospora beticola</i>	beet
Cercospora leaf spot of carrot	<i>Cercospora carotae</i>	carrot
Cercospora leaf spot of parsnip, turnip	<i>Cercospora</i> spp.	parsnip, turnip
chlorotic dwarf	<i>Maize chlorotic dwarf virus</i>	sweet corn
club root	<i>Plasmodiophora brassicae</i>	cole crops
common bacterial blight	<i>Xanthomonas campestris</i> pv. <i>phaseoli</i>	legumes
common rust	<i>Puccinia sorghi</i>	sweet corn
crater rot	<i>Rhizoctonia solani</i>	celery
cucumber mosaic	<i>Cucumber mosaic virus</i>	cucurbits, pepper,
cyst nematode disease	<i>Heterodera glycines</i>	legumes
damping-off	<i>Pythium</i> spp.	cilantro, dill, legumes, lettuce, onion, parsnip, spinach, and other vegetables
damping-off (greenhouse)	<i>Pythium</i> spp.	celery
downy mildew of basil	<i>Peronospora belbahrii</i>	basil
downy mildew of cole crops	<i>Hyaloperonospora parasitica</i>	cole crops
downy mildew of cucurbits	<i>Pseudoperonospora cubensis</i>	cucurbits
downy mildew of dill/parsnip	<i>Peronospora umbellifarum</i>	dill, parsnip
downy mildew of garlic/onion	<i>Peronospora destructor</i>	garlic, onion
downy mildew of lettuce	<i>Bremia lactucae</i>	lettuce
downy mildew of spinach	<i>Peronospora farinosa</i>	spinach
downy mildew of turnip	<i>Bremia parasitica</i>	turnip
drop (Sclerotinia rot)	<i>Sclerotinia sclerotiorum</i>	lettuce
dry rot	<i>Fusarium solani</i>	potato
dwarf mosaic	<i>Maize dwarf mosaic virus</i>	sweet corn

Diseases		
Disease	Pathogen	Host Crop
early blight of celery	<i>Cercospora apii</i>	celery
early blight of tomato	<i>Alternaria solani</i>	potato, tomato
foot rot of tomato	<i>Fusarium solani</i>	tomato
foot rot of sweet potato	<i>Plenodomus destruens</i>	sweet potato
fruit rot of cucurbits	<i>Fusarium solani f. sp. cucurbitae</i>	cucurbits
Fusarium crown and root rot	<i>Fusarium oxysporum f. sp. asparagi, F. proliferatum</i>	asparagus
Fusarium wilt of basil	<i>Fusarium oxysporum f. sp. basilicum</i>	basil
Fusarium wilt of watermelon	<i>Fusarium oxysporum f. sp. niveum</i>	watermelon
Fusarium wilt of sweet potato	<i>Fusarium oxysporum f. sp. batatas</i>	sweet potato
Fusarium wilt of tomato	<i>Fusarium oxysporum f. sp. lycopersici</i>	tomato
Fusarium wilt of legumes	<i>Fusarium oxysporum f. sp. phaseoli</i>	legumes
Fusarium wilt of okra	<i>Fusarium oxysporum f. sp. vasinfectum</i>	okra
gray leaf spot	<i>Cercospora zeae-maydis</i>	sweet corn
gummy stem blight/ black rot	<i>Didymella bryoniae</i>	cucurbits
late blight	<i>Phytophthora infestans</i>	potato, tomato
leaf mold	<i>Fulvia fulva</i>	tomato
lettuce mosaic	<i>Lettuce mosaic virus</i>	lettuce
northern corn leaf spot	<i>Bipolaris zeicola</i>	sweet corn
northern leaf blight	<i>Exserohilum turcicum</i>	sweet corn
Phytophthora blight	<i>Phytophthora capsici</i>	cucurbits, solanaceous
Phytophthora crown and spear rot	<i>Phytophthora asparagi</i>	asparagus
pink root	<i>Setophoma terrestris</i>	onion
Plectosporium blight	<i>Plectosporium tabacinum</i>	cucurbits
potato virus X	<i>Potato virus x</i>	potato
potato virus Y	<i>Potato virus y</i>	potato
powdery mildew of lettuce	<i>Erysiphe cichoracearum</i>	lettuce
powdery mildew of cole crops	<i>Erysiphe cruciferarum</i>	cole crops
powdery mildew of pepper/tomato	<i>Leveillula taurica</i>	pepper, tomato
powdery mildew of cucurbits	<i>Podosphaeria xanthii</i>	cucurbits
purple blotch	<i>Alternaria porri</i>	onion, garlic, leek
purple spot	<i>Stemphylium vesicarium</i>	asparagus
Rhizoctonia diseases	<i>Rhizoctonia solani</i>	cole crops
ring rot	<i>Clavibacter michiganensis subsp. <i>sepedonicus</i></i>	potato
ringspot	<i>Papaya ringspot virus</i>	cucurbits
root and crown rot	<i>Phytophthora</i> spp.	rhubarb
root-knot	<i>Meloidogyne</i> spp.	beet, carrot, cucurbits, potato,
root lesion	<i>Pratylenchus</i> spp.	potato
rust of asparagus	<i>Puccinia asparagi</i>	asparagus
rust of legumes	<i>Uromyces appendiculatus</i>	legumes

Diseases		
Disease	Pathogen	Host Crop
scab of cucurbits	<i>Cladosporium cucumerinum</i>	cucurbits
scab of potato	<i>Streptomyces scabies</i>	potato
scurf	<i>Monilochaetes infuscans</i>	sweet potato
Septoria blight of parsley	<i>Septoria petroselini</i>	parsley
Septoria leaf blight of tomato	<i>Septoria lycopersici</i>	tomato
Septoria leaf spot of radish	<i>Septoria lycopersici</i>	radish
Septoria leaf spot of mint	<i>Septoria menthae</i>	mint
silver scurf	<i>Helminthosporium solani</i>	potato
slippery skin	<i>Pseudomonas gladioli</i> pv. <i>alliicola</i>	onion
smut of onion/leek	<i>Urocystis colchici</i>	onion, leek
smut of corn	<i>Ustilago maydis</i>	sweet corn
sour skin	<i>Pseudomonas cepacia</i>	garlic, onion
southern blight	<i>Sclerotium rolfsii</i>	eggplant, pepper, tomato
southern corn leaf blight	<i>Bipolaris maydis</i>	sweet corn
southern rust	<i>Puccinia polysora</i>	sweet corn
spearmint rust	<i>Puccinia menthae</i>	mint
squash mosaic	<i>Squash mosaic virus</i>	cucurbits
Stemphylium leaf blight and stalk rot	<i>Stemphylium vesicarium</i>	garlic, leek, onion
Stewart's wilt	<i>Erwinia stewartii</i>	sweet corn
tobacco mosaic	<i>Tobacco mosaic virus</i>	potato, tomato
tomato spotted wilt	<i>Tomato spotted wilt virus</i>	tomato
Verticillium wilt	<i>Verticillium dahliae, Verticillium albo-atrum</i>	eggplant, mint, potato, tomato
watermelon mosaic	<i>Watermelon mosaic virus</i>	cucurbits
wheat streak mosaic	<i>Wheat streak mosaic virus</i>	sweet corn
white mold (timber rot)	<i>Sclerotinia sclerotiorum</i>	carrot, cole crops, eggplant, legumes, mint, pepper, potato, tomato
white rot	<i>Sclerotium cepivorum</i>	garlic, leek, onion
white rust	<i>Albugo candida</i>	cole crops, radish
yellows	<i>Fusarium oxysporum</i> spp.	cole crops
zucchini yellow mosaic	<i>Zucchini yellow mosaic virus</i>	cucurbits

# Asparagus

## Varieties

Hybrid varieties have improved vigor, disease tolerance, and higher yields, and are grown from seeds or crowns. All-male hybrids have higher yields and do not produce seed. Absence of seed production is desirable because seeds develop into volunteer asparagus seedlings that are a weed problem. Order hybrids well in advance.

All-male hybrids (listed in order of performance): Jersey General, Jersey Giant (56X22-8), Millenium, Jersey Knight, Jersey King, Jersey Supreme.

Other hybrids: Atlas, Purple Passion (specialty markets only).

Non-hybrids: Viking KB3, Mary Washington.

## Planting and Spacing

**Crowns:** Use only 1-year old crowns. Transplant April 15 to May 15. Use 4- to 5-foot rows with crowns 12 to 16 inches apart. Set the crowns in 8-inch furrows in light soils and 5- to 6-inch furrows in heavy soils. Cover with 2 to 3 inches of soil. Select deep, well-drained sandy loam soils. Hybrids should be planted slightly deeper. Start cultivating when spears begin to emerge, and continue periodically until furrows are level at end of first season.

**Seedling transplant:** 10- to 14-week old seedling transplants can be mechanically transplanted. Apply 4 ounces of transplant solution (10-52-17 or 9-45-15) to each transplant. Transplant in either the spring or fall.

## Harvesting

Harvest only 2 or 3 times in spring 1 year after transplanting. Thereafter, harvest for about 2 months in the spring. Harvest asparagus early in the morning for best quality. Allow the ferns to grow vigorously after this period to accumulate food reserves for the next season. As much care should be put into maintaining a healthy fern as into harvest.

## Fertilizing

**Lime:** To maintain a soil pH of 6.7 to 7.0. If possible, apply lime the year before planting.

**Preplant:** N: 70 pounds per acre.  $P_2O_5$ : 25 to 200 pounds per acre.  $K_2O$ : 0 to 250 pounds per acre. Adjust according to soil type, previous management, and soil test results

for your state. Broadcast the fertilizer, and plow it under when preparing the land for the planting furrows. Before planting new crowns, apply 100 pounds per acre of 8-32-0, or similar high phosphate starter fertilizer, in the bottom of the trench. Cover with 1 inch of soil before setting crowns.

**Yearly:** Each year after harvest, apply 50 pounds N per acre by broadcasting and incorporate by lightly tilling. No  $P_2O_5$  or  $K_2O$  is necessary if adequate fertilization was achieved prior to planting.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### *Crown and Root Rot of Asparagus - Fusarium Fungus*

Avoid fields with a history of crown and root rot. The disease is promoted by acidic (low pH) and poorly drained soil. Use tolerant, vigorous varieties if available. Establish production fields with blemish-free crowns produced in virgin soil or fumigated soil.

**Cannonball WG® (fludioxonil)** 0.5 oz. per 100 gals. of water. Michigan only: applicators must have 24c label. Michigan label expires Dec 31, 2022. REI: 12-hour. PHI: 365-day.

#### *Crown and Spear Rot of Asparagus - Phytophthora Oomycete*

Avoid excessive irrigation. Establish production fields from blemish-free crowns obtained from virgin soil or fumigated soil.

**Ridomil Gold SL® (mefenoxam)** 1 pt. per acre. See label. REI: 48-hour. PHI: 1-day.

**Ultra Flourish® (mefenoxam)** 2 pts. per acre. See label. REI: 48-hour. PHI: 1-day.

### **Leaf Spot of Asparagus - *Cercospora* Fungus**

Leaf spot of asparagus caused by *Cercospora asparagi* is also called Cercospora blight.

**Dexter Max® (mancozeb, azoxystrobin)** 2-2.2 lbs. per acre. See label. REI: 24-hour. PHI: 180-day.

**Dexter Xcel® (mancozeb, azoxystrobin, tebuconazole)** 64 fl. oz. per acre. Max application: 1.5 gallons per acre per crop. REI: See label. PHI: 180-day.

### **Purple Spot of Asparagus - *Stemphylium* Fungus**

Reduce crop residues by removing or mowing senescent and dried ferns in the fall/winter. TOM-CAST can help asparagus farmers schedule their fungicide applications for control of purple spot. See Disease Forecasting Systems (page 84) for more details. NOTE: Products labeled for rust may be helpful for purple spot control.

**azoxystrobin formulations (azoxystrobin)** 6-15.5 fl. oz. per acre. Products include Aframe®, Aries 250®, Azoxy 2SC Prime®, Quadris Flowable®, Satori®, Trevo®, and Willowood Azoxy 2SC®. See product labels for various rates. REI: 4-hour. PHI: 100-day.

**chlorothalonil formulations (chlorothalonil)** Products include Bravo®, Chloronil®, Echo®, Equus®, Initiate®, and Praiz®. See product labels for various rates. REI: 12-hour. PHI: 190-day.

**Dexter Max® (mancozeb, azoxystrobin)** 2-2.2 lbs. per acre. See label. REI: 24-hour. PHI: 180-day.

**Dexter Xcel® (mancozeb, azoxystrobin, tebuconazole)** 64 fl. oz. per acre. Max application: 1.5 gallons per acre per crop. REI: See label. PHI: 180-day.

**Flint Extra® (trifloxystrobin)** 3-3.8 fl. oz. per acre. Apply on a 14-day interval as needed. Make applications to the fern stage only. Mow down the asparagus ferns (or allow the ferns to senesce) between the last fungicide application and harvest. REI: 12-hour. PHI: 180-day.

### **Rust of Multiple Crops - *Puccinia* Fungus**

Reduce crop residues that may harbor the pathogen by removing or mowing senescent and dried ferns in the fall/winter. Scout for the early appearing bright orange aecial pustules in the spring, especially on new or young plantings that are not harvested the full season. Remove volunteer plants on field edges and ditchbanks. Plant crop rows with ample spacing and in the direction of the prevailing winds to increase air movement and minimize periods of prolonged leaf wetness.

**chlorothalonil formulations (chlorothalonil)** Products include Bravo®, Chloronil®, Echo®, Equus®, Initiate®, and Praiz®. See product labels for various rates. REI: 12-hour. PHI: 190-day.

**Dexter Max® (mancozeb, azoxystrobin)** 2-2.2 lbs. per acre. See label. REI: 24-hour. PHI: 180-day.

**Dexter Xcel® (mancozeb, azoxystrobin, tebuconazole)** 48-64 fl. oz. per acre. Max application: 1.5 gallons per acre per crop. REI: See label. PHI: 180-day.

**mancozeb formulations (mancozeb)** Products include Dithane®, Fortuna®, Koverall®, Manzate®, Penncozeb®, and Roper®. See product labels for various rates. REI: 24-hour. PHI: 180-day.

**Rally 40WSP® (myclobutanil)** 5 oz. per acre. See label. REI: 24-hour. PHI: 180-day.

**Sonoma 40WSP® (myclobutanil)** 5 oz. per acre. See label. REI: 24-hour. PHI: 180-day.

**tebuconazole formulations (tebuconazole)** Products include Buzz Ultra DF,® Monsoon®, Omni Brand Tebuconazole®, Onset 3.6L®, Orius 3.6F®, Tebucon 3.6F®, Tebuconazole 3.6 Select®, Tebucure 3.6®, Tebustar 3.6L®, Tebuzol 3.6F®, Tide Tebu 3.6F®, Toledo 3.6F®, Vibe®, and Willowood Teb 3.6SC®. See product labels for various rates. REI: see label. PHI: 180-day.

**Unicorn DF® (tebuconazole, sulfur)** 2-3.75 lbs. per acre. See label. REI: see label. PHI: 180-day.

## **Weed Control**

Before establishing an asparagus planting, reduce perennial weeds in the area to be planted. Good weed control in the planting year is especially important. Herbicide options are limited in the planting year, so cultivation and hand hoeing may be needed to achieve good control.

A typical weed control program in asparagus includes a preemergence herbicide with a long residual applied before asparagus emerges. If needed, a preemergence herbicide may be applied again after harvest is finished. Postemergence herbicides are also available — some may be applied before asparagus emerges, others may be applied during or after the harvest season, and some require directed or shielded spray applications to avoid spraying asparagus.

It is important use herbicides with different modes of action from year to year to avoid buildup of weed species not controlled by a particular mode of action. When herbicides are not used, weed control methods include cultivation, hand-weeding, flaming, mowing, and mulching. Avoid damaging crowns when cultivating.

## Recommended Controls

### Preemergence Broadleaf and Grass Weeds

**Chateau SW® (flumioxazin)** 6 oz. per acre. Established plantings only. Apply to dormant asparagus at least 2 weeks before spears emerge. Crop injury may result if asparagus is not dormant. May be tank-mixed with paraquat to control emerged weeds. Or, apply after final harvest for the season before fern emerges. Do not exceed 6 oz. per acre per growing season. REI: 12-hour.

**Command 3ME® (clomazone)** 2.6 pts. per acre. Apply prior to spear emergence or apply after a clean harvest. Cover exposed plants with soil before applying. Do not exceed 2.6 pts. per acre per year. REI: 12-hour. PHI: 14-day.

**diuron formulations (diuron)** Established plantings only. Do not apply to young plants during the first year. Use 80DF formulations at 1-4 lbs. per acre, and do not exceed 6 lbs. per acre per season. Use 4L formulations at 0.8-3.2 qts. per acre and do not exceed 4.8 qts. per acre per season. Use lower rates on light-colored soils with less than 2% organic matter. Apply after tillage or chopping fern in the spring and again after harvest, if necessary. See product label for split application rates. 6-8 weeks of residual activity. REI: 12-hour.

**Dual Magnum® (s-metolachlor)** 1.33-2.0 pts. per acre. *Michigan and Indiana only - applicators must have 24c label.* Michigan label expires Dec 31, 2021. Apply before asparagus and weeds emerge in spring or after the harvest season. Needs moisture for activation. Do not exceed 1 application per crop. REI: 24-hour. PHI: 16-day.

**metribuzin formulations (metribuzin)** Established plantings only. Do not apply to young plants during first year. Use 75DF formulations at 0.6-2.6 lbs. per acre. Use 4F formulations at 2-4 pts. per acre. See product label for split application rates. Use low rate if combined with diuron. 6-8 weeks residual activity. Two sprays necessary for season-long sandbur control. Do not exceed 2.6 lbs. or 4 pts. per acre per year. REI: 12-hour. PHI: 14-day.

**Prowl H2O® (pendimethalin)** 2.4-8.2 pts. per acre. Apply at least 14 days before first harvest and prior to spear emergence. If spears are present, remove before application. On sandy soil use no more than 2.4 pts. per acre. Do not apply to newly seeded asparagus during first year. REI: 24-hour. PHI: 14-day.

**Sinbar WDG® (terbacil)** 0.62-1.5 lbs. per acre.

Established crowns or direct-seeded crops only. Do not use on sandy soil or on soil with less than 1% organic matter. Established crowns: Apply in spring after cutting fern and prior to spear emergence. May also be applied after a clean cutting. Seeded crops: At planting spray activated charcoal at 300 lbs. per acre of actual area treated in a 1-inch band over the row (equivalent to 15 lbs. per acre of crop with 20-inch row spacing), then apply Sinbar. Do not plant other crops within 2 years of application. 8-12 weeks residual activity. REI: 12-hour. PHI: 5-day.

### Solicam DF® (norflurazon)

2.5-5 lbs. per acre. Established plantings only. Do not apply within 12 months of planting. Apply preemergence to soil free of weeds and debris. REI: 12-hour. PHI: 14-day.

### Spartan 4F® (sulfentrazone)

4.5-12 fl. oz. per acre. *Michigan only - applicators must have a supplemental label.* Established crowns only. Apply in spring before crop emerges. Use low rate on light soil. Do not use on soils with less than 1% organic matter. Do not exceed 1 application and 12 fl. oz. per acre per year. REI: 12-hour. PHI: 14-day.

### trifluralin formulations (trifluralin)

Established plantings only. Use 4EC formulations at 2-4 pts. per acre. Use 10G formulations at 10-20 lbs. per acre. Use lower rates on coarse soils. Apply and incorporate 1-2 inches early in the spring when spears are at least 4 inches below soil surface. See product label for split application instructions. 4-6 weeks of residual activity. REI: 12-hour.

### Preemergence Broadleaf Weeds

**Callisto® (mesotrione)** 6-7.7 fl. oz. per acre. Apply in spring before spears emerge after mowing, disking, or tilling; after final harvest; or both. For postharvest applications use drop nozzles or other equipment that minimizes contact with crop. Adding COC or NIS (alone or with UAN or AMS) improves emerged weed control and increases crop injury risk in postharvest applications. Do not exceed 2 applications per year, or 7.7 fl. oz. per acre per year. REI: 12-hour.

**Lorox DF® (linuron)** 2-4 lbs. per acre. Do not use on sand, loamy sand, or soils with less than 1% organic matter. Established crowns: Apply before spears emerge, before cutting season or immediately after cutting, or as directed spray in ferns. Newly seeded crops: Apply a 1-inch band of activated charcoal over the row at planting, then apply Lorox®. Use charcoal at 300 lbs. per acre of actual area sprayed which is

equivalent to 15 lbs. per acre of crop with a 20-inch row-spacing. Or, use the low rate of Lorox® when ferns are 6-18 inches tall and weeds are less than 4 inches tall. Maximum 4 lbs. or 3 applications per acre per year. REI: see label. PHI: 1-day.

### **Postemergence Broadleaf and Grass Weeds**

**glyphosate formulations (glyphosate)** 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal) at 0.66-3.3 qts. per acre. Apply to emerged weeds at least 7 days before spears emerge or immediately after last harvest. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. If spears are allowed to regrow, delay application until ferns have developed and apply as a directed or shielded spray. Contact of the spray with asparagus fern may result in crop injury. REI: 4-hour. PHI: 14-day.

### **Gramoxone SL 2.0° (paraquat)** 2.5-4 pts. per acre.

Include 1 qt. of COC, or 4-8 fl. oz. of NIS per 25 gallons of spray solution. Apply before crop emergence or after last harvest before fern regrows. REI: see label. PHI: 6-day. RUP.

**QuinStar 4L° (quinclorac)** 12.6 fl. oz. per acre. Include 1 qt. of COC per 25 gallons of spray solution. Apply after final harvest for the year. Controls bindweed, Canada thistle, barnyardgrass, large crabgrass. Do not exceed 1 application per year. REI: 12-hour.

### **Postemergence Broadleaf Weeds**

**2,4-D amine formulations (2,4-D)** Use 3-4 pts. per acre of liquid formulations with 3.8 lbs. per gal. acid equivalent. Apply before, during, or after the harvest season. During harvest season apply immediately after cutting. Discard deformed spears. Use drop nozzles for treatments after harvest to avoid spraying fern. REI: 48-hour. PHI: 3-day.

**Aim EC° (carfentrazone)** 0.5-1.92 gals. per acre. Include 0.5 pt. NIS or 0.25-0.5 gals. COC per 25 gals. of spray solution. Broadcast after spear harvest. Emerged asparagus will be injured. Do not exceed 3.8 fl. oz. per acre per season. Wait at least 20 days between applications. REI: 12-hour. PHI: 5-day.

**Callisto° (mesotrione)** 3 fl. oz. per acre. Apply in spring before spears emerge after mowing, disking, or tilling; after final harvest; or both. For postharvest applications use drop nozzles or other equipment that will minimize contact with crop. Adding COC or NIS (alone or with UAN or AMS) improves



Harvest asparagus spears in the morning for best quality.

emerged weed control and increases crop injury risk in postharvest applications. Do not exceed 2 applications per year, or 7.7 fl. oz. per acre per year. REI: 12-hour

**Clarity° (dicamba)** 0.5-1.0 pt. per acre. Apply in 40-60 gals. of water per acre immediately after cutting. Discard crooked spears at harvest. Clarity can injure nearby broadleaf crops and garden plants. Maximum 1 pt. per acre per year. REI: 24-hour. PHI: 24-hour.

**Lorox DF° (linuron)** 1-3 lbs. per acre. Do not use on sand, loamy sand, or soils with less than 1% organic matter. Established crowns: Apply before cutting season or immediately after cutting. Newly seeded crops and newly planted crowns: Apply 1-2 lbs. per acre, up to 2 applications when ferns are 6-18 inches tall. Maximum 4 lbs. and 3 applications per acre per year for established crowns. REI: see label. PHI: 1-day.

**Savage WSG° (2,4-D)** 1.5-2 lbs. per acre. Apply before, during, or after harvest. During harvest season apply immediately after cutting. Discard deformed spears.

**Herbicides for Asparagus<sup>1</sup>**

Product (REI/PHI)	Common Name	Timing and Application	Location Relative to Crop	Timing Relative to Weeds		Weed Groups Controlled
				OK on Young Plantings?	Preemergence	
Aim EC® (12h/5d)	carfentrazone	X	X	X	X	X
Callisto 4L® (12h/-)	mesotrione	X	X	X	X	X
Chateau® (12h/-)	flumioxazin	X		No	X	X
Clarity 4L® (24h/1d)	dicamba		X		X	X
Command 3ME® (12h/14d)	clomazone	X	X		X	X
Diuron®, others (12h/-)	diuron	X	X		No	X
Dual Magnum®	metolachlor	X	X		yes	X
Fusilade DX 2E® (12h/1d)	fluazifop	X	X	X	Yes	X
Gramoxone® (12h to 24h/6d)	paraquat	X	X		yes	X
Lorox 50DF® (12h/ 1d)	linuron	X	X		Yes	X
Roast® (12h/1d)	sethoxydym	X	X		Yes	X
Prowl H2O® (12h/14d)	pendimethalin	X			X	X
Quinstar 4L® (12h/-)	quinclorac		X		X	X
Roundup®, others (12h/-)	glyphosate	X	X		yes	X
Sandea® (12h/1d)	halosulfuron	X	X	X	Yes	X
Savage WSG®, others (48/h)	2,4-D amine	X	X	X		X
Select Max®, others (12h/1d)	clethodim	X	X	X	Yes	X
Sencor 4E® or 75DF (12h/14d)	metribuzin	X	X		No	X
Sinbar® (12h/5d)	terbacil	X			No	X
Solicam DF® (12h/ 14d)	norflurazon	X			No	X
Spartan®	sulfentrazone	X			Yes	X
Spur®	clopyralid	X	X		Yes	X
Treflan®, others (12h/-)	trifluralin	X			No	X

<sup>1</sup>For effectiveness against specific weeds, see Relative Effectiveness of Herbicides for Vegetable Crops (page 68), and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbicides can cause serious crop injury and yield loss if not used properly.

Use drop nozzles for treatments after harvest to avoid spraying fern. Maximum 2 applications during the harvest season. Wait at least 30 days between applications. REI: 48-hour. PHI: 3-day.

**Sandeia® (halosulfuron)** 0.5-1.5 oz. per acre. Apply before, during, or after harvest. Drop nozzles and using COC or NIS are recommended for applications after harvest. For first year transplants do not apply sooner than 6 weeks after fern emergence. Do not exceed 2 applications per crop cycle, or 2 oz. per acre per 12-month period. Has residual soil activity. Effective on nutsedge. REI: 12-hour. PHI: 1-day.

**Spur® (clopypralid)** 8-10.7 fl. oz. per acre. Apply before or during harvest. May cause some crooking of spears. Controls Canada thistle, marestail, mayweed, nightshade, plantain, smartweeds. Do not exceed 10.7 fl. oz. per acre per year. Avoid application 2 years in succession. REI: 12-hour. PHI: 2-day.

### **Postemergence Grass Weeds**

**clethodim formulations (clethodim)** Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max® at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per season. REI: 24-hour. PHI: 1-day.

**Fusilade DX® (fluazifop-P)** 8-12 fl. oz. per acre. Include 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gals. of spray solution. Spray on actively growing grass. Rates may be doubled if asparagus will not be harvested for 12 months. Wait at least 14 days between applications. Do not exceed 48 fl. oz. per acre per season on bearing asparagus. REI: 12-hour. PHI: 1-day.

**Poast® (sethoxydim)** 1-1.5 pts. per acre. Include 1 qt. COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5 pts. per acre per season. REI: 12-hour. PHI: 1-day.

## **Insect Control**

### **Recommended Controls**

#### **Aphids**

**Assail 30SG® (acetamiprid)** 2.5-5.3 oz. per acre. Do not exceed 2 applications per season. Do not exceed 10.7 oz. per acre per season. Do not apply more than once every 10 days. REI: 12-hour. PHI: 1-day.

**chlorpyrifos formulations (chlorpyrifos)** 2 pts. per acre for 4E formulations. 1.33 lbs. per acre for 75WG formulations. Do not make more than one preharvest application. Do not make more than 2 postharvest applications during the fern stage. Broadcast with ground equipment. REI: see label. PHI: 1-day. *RUP*.

**Fulfill® (pyrmetrozine)** 2.75 oz. per acre. Apply to fern only after harvest has been completed. Allow a minimum of 30 days between applications. Do not exceed 16.5 oz. per acre per season. REI: 12-hour. PHI: 170-day.

#### **Armyworm Caterpillars**

**chlorpyrifos formulations (chlorpyrifos)** 2 pts. per acre for 4E formulations. 1.33 lbs. per acre for 75WG formulations. Do not make more than one preharvest application. Do not make more than 2 postharvest applications during the fern stage. Broadcast with ground equipment. REI: see label. PHI: 1-day. *RUP*.

**Coragen® (chlorantraniliprole)** 3.5-5.5 fl. oz. per acre. Do not exceed 4 applications per season. Do not exceed 15.4 fl. oz. per season. Minimum interval between treatments is 3 days. REI: 4-hour. PHI: 1-day.

**Lannate LV® (methomyl)** 1.5-3 pts. per acre. Do not exceed 8 applications per season. REI: 48-hour. PHI: 1-day. *RUP*.

#### **Asparagus Beetles**

*At Harvest:* Treat when 5-10% of plants are infested, or 2% of spears have eggs.

*At Fern:* Treat when 10% of plants are defoliated, or 50% of plants have larvae.

**Assail 30SG® (acetamiprid)** 2.5-5.3 oz. per acre.

For control on spears during harvest, to prevent egg laying and feeding injury. Do not exceed 2 applications per season. Do not exceed 10.7 oz. per acre per season. Do not apply more than once every 10 days. REI: 12-hour. PHI: 1-day.

**chlorpyrifos formulations (chlorpyrifos)** 2 pts. per acre for 4E formulations. 1.33 lbs. per acre for 75WG formulations. For control on spears during harvest, to prevent egg laying and feeding injury. Do not make more than one preharvest application. Do not make more than 2 postharvest applications during the fern stage. Broadcast with ground equipment. REI: see label. PHI: 1-day. *RUP*.

**Dimethoate 400® (dimethoate)** 1 pt. per acre. Do not exceed 2 pts. per acre per season. REI: 48-hour. PHI: 180-day.

**Entrust® (spinosad)** 4-6 fl. oz. per acre. Do not exceed 18 fl. oz. per acre per season. REI: 4-hour. PHI: 60-day. OMRI-listed.

**Lannate LV® (methomyl)** 1.5-3 pts. per acre. Do not exceed 8 applications per season. REI: 48-hour. PHI: 1-day. RUP.

**Perm-Up 3.2EC® (permethrin)** 2-4 fl. oz. per acre. Do not exceed 16 fl. oz. per acre per season. Minimum interval between treatments in 7 days. REI: 12-hour. PHI: 1-day. RUP.

**Radiant 1SC® (spinetoram)** 4-8 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 4-hour. PHI: 60-day.

**Sevin XLR Plus® (carbaryl)** 1-2 qt. per acre. Use low rate for control on seedlings and or spears during harvest, to prevent egg laying and feeding injury. Use high rate for control on fern growth after harvest is over. Do not exceed more than 5 applications to spears and ferns combined. Do not exceed 5 qts. per acre per year. Do not treat more than once every 3 days. REI: 12-hour. PHI: 1-day.

### **Cutworm Caterpillars**

*At harvest:* Treat when 5% of crowns are infested.

*In fall:* Treat when 1 larva per 20 plants.

**Assail 30SG® (acetamiprid)** 2.5-5.3 oz. per acre.

For control on spears during harvest, to prevent egg laying and feeding injury. Do not exceed 2 applications per season. Do not exceed 10.7 oz. per acre per season. Do not apply more than once every 10 days. REI: 12-hour. PHI: 1-day.

**chlorpyrifos formulations (chlorpyrifos)** 2 pts. per acre for 4E formulations. 1.33 lbs. per acre for 75WG formulations. For control on spears during harvest, to prevent egg laying and feeding injury. Do not make more than one preharvest application. Do not make more than 2 postharvest applications during the fern stage. Broadcast with ground equipment. REI: see label. PHI: 1-day. RUP.

**Lannate LV® (methomyl)** 3 pts. per acre. Do not exceed 8 applications per season. REI: 48-hour. PHI: 1-day. RUP.

**Perm-Up 3.2EC® (permethrin)** 2-4 fl.oz. per acre. Do not exceed 16 fl. oz. per acre per season. Minimum interval between treatments in 7 days. REI: 12-hour. PHI: 1-day. RUP.

**Sevin 5B® (carbaryl)** 20 lbs. per acre. For control on spears during harvest, to prevent egg laying and feeding injury. Do not exceed more than 3 applications to spears. Do not exceed 2 applications to ferns. Do not exceed 60 lbs. per acre per season on spears, and 80 lbs. per acre per season on ferns (100 lbs. per acre per season total). Minimum days between treatment is 3 days. REI: 12-hour. PHI: 1-day.

**Sevin XLR Plus® (carbaryl)** 1-2 qt. per acre. Use low rate for control on seedlings and or spears during harvest, to prevent egg laying and feeding injury. Use high rate for control on fern growth after harvest is over. Do not exceed more than 5 applications to spears and ferns combined. Do not exceed 5 qts. per acre per year. Do not treat more than once every 3 days. REI: 12-hour. PHI: 1-day.

### **Japanese Beetle**

**Assail 30SG® (acetamiprid)** 5.3 oz. per acre. Apply to fern only after harvest has been completed. Do not exceed 2 applications per season. Do not exceed 10.7 oz. per acre per season. Do not apply more than once every 10 days. REI: 12-hour. PHI: 1-day.

**Perm-Up 3.2EC® (permethrin)** 4 fl. oz. per acre. Do not exceed 16 fl. oz. per acre per season. Minimum interval between treatments in 7 days. REI: 12-hour. PHI: 1-day. RUP.

### **Tarnished Plant Bug**

**Assail 30SG® (acetamiprid)** 5.3 oz. per acre. Apply to fern only after harvest has been completed. Do not exceed 2 applications per season. Do not exceed 10.7 oz. per acre per season. Do not apply more than once every 10 days. REI: 12-hour. PHI: 1-day.

**Perm-Up 3.2EC® (permethrin)** 4 fl. oz. per acre. Do not exceed 16 fl. oz. per acre per season. Minimum interval between treatments in 7 days. REI: 12-hour. PHI: 1-day. RUP.

# Asian Vegetables

U.S. demand for ethnic vegetables is increasing rapidly — from a growing ethnic Asian population and from health-conscious consumers seeking variety.

Asian vegetables are those that have originated from East Asia (China, Japan, and Korea) and Southeast Asia (Indonesia, Laos, the Philippines, Singapore, Thailand, Vietnam, etc.). Most Asian vegetables are not well-known to American farmers, because they are typically cultivated by the Asian growers exclusively for Asian-Americans. However, some of these Asian vegetables may be considered as options for Midwest producers.

The information below should be considered an introduction to Asian vegetables. More detailed information can be found in the resources section. General pest management recommendations for the crop families described below can be found in the corresponding crop chapters in this Guide. Although not all of the Asian vegetable crops mentioned in this chapter will be associated with pesticides in the crop chapters of this guide, more detailed information can be found on the pesticide label.

## Marketing

Growers might consider Asian vegetables in double crop situations (such as following a wheat or early cabbage or sweet corn crop). Growers who want to diversify their farming operations by including Asian vegetables need to be very cautious before beginning production. Marketing information for Asian crops is not widely published. Since Asian crops are niche items, only specialized produce companies deal in them. Most of these buyers deal with restaurants, some chain stores, and specialty food stores.

Do your homework. Establish markets and buyers before buying any seed. Calculate budgets and collect economic data on any crop to determine its profit potential. And remember that all Asian crops are very labor intensive, so you will need a strong and dependable labor force for timely harvest and proper cultural management.

## Common Asian Vegetables

Asian vegetables have different names in different languages. You must properly identify the crop to market it properly and to select the appropriate pest control measures.

### ***Cole Crops and Brassica Leafy Greens***

#### ***Cole Crops***

The term “cole crops” refers to leafy brassicas, with waxy leaves, of the species. Cabbage, cauliflower, broccoli, Brussels sprouts, kale, kohlrabi, daikon radish, and Chinese cabbage are hardy crops and well adapted to cool weather. Careful selection of the planting date and the cultivars to grow is crucial to a good harvest in the Midwest. Plants maturing under cool weather conditions are the highest in quality. This diverse family of cole crops has similar diseases, insects, and nutrient requirements.

**Cabbage:** Among the brassica crops, cabbage is the easiest to grow and the most widely grown. There are varieties of cabbage that mature in as little as 60 days and others that mature in as much as 120 days from transplanting. Small-headed varieties of cabbage (3-4 lbs.) are the most desired varieties for fresh market sales.

**Cauliflower:** Cauliflower is relatively more difficult to grow than cabbage. The most common problems associated with cauliflower production are failure to head properly and poor curd quality. A fertile, moist soil and high level of organic matter and nitrogen in the soil are needed for a successful production of cauliflower. Cauliflower buttoning is the premature formation of curd. When the curd is formed very early in the plant's life, the leaves of the plant are not large enough to sustain its development to a marketable size. Cold temperatures at transplanting slow vegetative growth and encourage buttoning. Cauliflower varieties range in maturity from 55 to 95 days.

**Broccoli:** Broccoli is not as demanding in its requirements as cauliflower. However, it must be harvested as soon as the head is mature to avoid flowering. During the critical period of head formation, prolonged periods of heat (over 85°F.) result in poor head quality. Broccoli varieties range in maturity from 55 to 75 days.

**Brussels sprouts:** Brussels sprouts are generally long season crops grown for harvest in the fall. They should be harvested when the buds are about 1 inch in diameter, firm, tight and of good color. The crop can be harvested as buds or stacks. Harvesting the Brussels sprouts as stalks saves on labor and extends the shelf life of the buds.

**Kale:** Kale is hardy and grows best as a fall crop when grown for full-size leaves. It can also be succession planted all season and may be grown as a component of a salad mix. Flowering kale varieties may be grown as ornamental crops and are susceptible to tip burn during hot weather. The flavor of edible kale is best after a light frost.

**Kohlrabi:** Kohlrabi looks like a turnip growing on top of the ground with sprouting leaves over the surface. It must be harvested when its diameter reaches 1 1/2 to 2 inches for best quality. Larger sizes may be tough and stringy.

**Daikon Radish** (*Raphanus sativus*, var. *longipinnatus*) is also called Chinese radish and is closely related to the common radish crop. The main planting time for daikon is spring and fall, but some varieties can be planted almost year-round. The seeds need to be planted very close to the surface (3/4 inch deep) as they need light to germinate. April planting generates spring harvest, and July planting generates fall harvest. Spacing should be 4 to 6 inches within the rows and 3 feet between rows. To accommodate the large roots, daikon needs to be planted in high raised beds that are amended with organic matter, such as compost. At each cultivation time, the soil needs to be worked higher and higher around the roots, as they grow, to prevent photosynthesis and greening of the root. Most daikon radishes reach their useable size in 60-70 days.

### ***Brassica Leafy Greens***

Chinese cabbage (*Brassica napa*), and Mustard greens (*Brassica juncea*) are grown as salad or braising greens or as heading crops. Their leaves are not waxy, and most of them are Asian in origin. They can be grown as components of a salad mix. Crops in this group are more susceptible to damage from flea beetles but tend to be less attractive to caterpillars than other cole crops. Chinese cabbage is especially sensitive to bolting in response to cold temperatures and other stressful conditions. Nitrogen management for Chinese cabbage is slightly different than that of cole crops.

**Chinese cabbage:** Chinese cabbage has been grown in Asia since the fifth century. It is a cool-season annual vegetable. It grows best with short days and moderate to cool temperatures (60-70°F.). Its cultural requirements are similar to those of cabbage and lettuce. Chinese cabbage is fairly quick to mature. It varies from 40 days from sowing to harvest for some cultivars to 75 days for the longer-maturing ones. Chinese cabbage is a term applied to a wide range of types and varieties. The main types and varieties of Chinese cabbage are:

### ***Group I:***

Napa cabbage (*Brassica campestris*) is commonly called the pe-tsai group. Its common names also include celery cabbage, Chinese white cabbage, Peking cabbage, pe-tsai, won bok, nappa (Japanese), hakusai (Japanese), pao, and hsin pei tsai. Napa cabbage includes broad-leaved, compact-heading varieties of which there are two forms, Chihili and Che-foo. Napa cabbage needs to be spaced 18 inches within the rows and 24 inches between rows.

Chihili forms of Napa cabbage form a cylindrical head 18 inches long and 6 inches in diameter, with an erect, upright growing habit. Some varieties of this form are Chihili, Michihli, Market Pride, Shantung, and Shaho Tsai.

Che-foo types form a compact, round head of green-bladed, white petioled leaves. Some varieties in this group are Che-foo, Tropical Pride, and Oriental King.

### ***Group II:***

Bok choy (*Brassica campestris*) is sometimes called *Brassica chinensis*. The most commonly accepted designations are bok choy or pak choy. Many refer to it as Chinese mustard.

Bok choy is a non-heading form of Chinese cabbage, with several thick white leafstalks. The smooth, glossy, dark green leaf blades form a celery-like cluster. Bok choy need to be spaced 8-12 inches within the row and 24 inches between rows. There are not as many varieties of bok choy as there are of the Napa cabbage. Bok choy varieties include Canton Choice and Long White Petiole.

Many other brassica greens, such as mizuna, mibuna, tatsoi, komatsuna, arugula, and mustard are usually direct seeded. Some varieties are prone to premature flowering, which is enhanced by cold temperatures in the spring. Transplanting, which is less common than direct seeding, can also increase premature flowering in the spring due to increased plant stress. Plant populations vary tremendously and should be geared toward the intended harvest age and size.

## Cucurbit Vegetables

Includes bittermelon, edible luffa gourd, winter melon.

**Bittermelon** (*Mormodica charantia*): This vegetable is a native of India. Like cucumbers and squashes, bittermelon is a member of the Cucurbit family. It is a warm-season vegetable. It is usually grown on a trellis system and its fruit is about the size of a summer squash. The trellis should be 6-feet high and 4-6 feet apart. The seeds can be directly planted or grown as seedlings with spacing at 1.5-2 feet between plants and 3-5 feet between rows. Bittermelon is harvested green before there is any color change. Bright orange fruits are saved for seed collection.

**Edible Luffa:** The edible luffas come in two forms: smooth and angled.

Smooth luffa, *Luffa cylindrica*, originated in India and was later taken to China. It is mainly grown for the young squash-like fruits. Some of the luffa cultivars are Smooth Boy, Smooth Beauty, and Southern Winner. If left to mature on the plant, smooth luffa gourd produces the familiar “Luffa sponge” found in stores. Luffa plants are warm-season vegetables and need to be trellised.

Angled Luffa, *Luffa actuangula*, is very similar to the smooth luffa. Luffa gourds are trained on trellises to encourage straighter fruits, which can become more curved if allowed to grow on the ground. Just like smooth luffa, the angled luffa is a warm-season annual vegetable. The quality of this squash as a sponge gourd is not as desirable; however, in stir fries and other foods it excels. Some of the angled luffa cultivars are Hybrid Green Glory, Hybrid Asian Pride, Lucky Boy, and Summer Long.

## Legumes

Includes asparagus (yardlong) bean, edible snap sugar peas, snow peas.

**Asparagus (Yardlong) Bean** (Chinese Long Bean, *Vigna sesquipedalis*): This long, trailing vine should be grown on trellises. This plant is more closely related to black-eyed pea than to the common green snap bean. Dark and light green varieties are available as well as a red type. The darker varieties are generally preferred. It is a warm-season vegetable. Yardlong beans are cut into 2-inch pieces and added to various stir fries. The paler green is sweeter and more tender than the dark green.

**Sugar Snap Pea and Snow Pea** (*Pisum sativum*): These cool-season vegetables should be sowed in April for a spring crop or sowed in July for a fall crop. Plants deteriorate quickly in the heat of summer. The plants of sugar snap pea and snow pea grow similarly to bush beans. It is often helpful to grow them on trellises to facilitate picking; however, if grown for the tender shoot tips, they are usually left untrellised.

## Fruiting Vegetables

Includes Oriental eggplant.

**Oriental Eggplants** (*Solanum melongena*): This crop is native to tropical Asia and are very popular in Japan, China, India, Thailand, and the Philippines. Many varieties are available. They can be light or dark purple, brown, or green in skin color; and round and slender in shape.

Eggplants require full sun and well-drained soil. Eggplants must have warm soil to grow well and they take a long time to reach maturity. Hence, it is a good idea to start seedlings in a greenhouse and set the transplants in the field after the danger of frost is over. Transplant eggplants 18-24 inches apart in rows 30-36 inches apart between rows. Eggplants grow best in hot weather. Water the plants during dry spells. Harvest usually begins in mid- to late summer, about 70-90 days after sowing seeds. Harvest eggplants when the fruit reaches the right size and when skin is glossy and firm. Fruit sizes vary depend on the variety.

## Resources

“Ethnic Vegetables: Asian,” University of Kentucky Extension, <https://www.uky.edu/ccc/content/ethnic-vegetables-asian>

“Asian Vegetables: Selected Fruit and Leafy Types,” Purdue University Center for New Crops and Plants Products, [www.hort.purdue.edu/newcrop/proceedings1996/v3-488.html](http://www.hort.purdue.edu/newcrop/proceedings1996/v3-488.html)

“Asian Vegetables,” Purdue University Center for New Crops and Plants Products, [www.hort.purdue.edu/newcrop/proceedings1990/V1-387.html](http://www.hort.purdue.edu/newcrop/proceedings1990/V1-387.html)

*Speciality and Minor Crops Handbook*, second edition, University of California Agriculture and Natural Resources publication 3346, available from ANRCatalog, [anrcatalog.ucdavis.edu](http://anrcatalog.ucdavis.edu)

*Manual of Minor Vegetables*, University of Florida IFAS publication SP 40, available from IFAS Extension Bookstore, [ifasbooks.ifas.ufl.edu](http://ifasbooks.ifas.ufl.edu)

# Celery

## Spacing

Typical spacing for celery is rows 2 feet apart with plants 6 inches apart in row. One plant per square foot.

## Soils

Traditionally, celery has been grown on muck soils, but it can be grown on coarse-textured mineral soils. Regardless of soil type, high fertility and moisture are necessary for tender succulent stalks.

Use overhead sprinkler or drip irrigation to apply water and fertilizer frequently to the shallow-rooted crop. If the soil gets too dry, physiological disorders such as blackheart (a calcium deficiency), will develop.

Rotate celery with such commodities such as onions or corn whenever possible to avoid building up pests in the soil. At the end of the season, consider planting a winter cover crop of barley or rye to reduce erosion and add active organic matter to the soil.

## Transplants

Celery seed is small and difficult to germinate, thus all commercial celery is planted from greenhouse-grown transplants produced in plug trays using peat-based media. Allow 8 to 10 weeks for transplant production.

In early February, seeds are sown in greenhouses and are ready for transplanting to the field in about eight weeks. Transplanting begins in April and ends in late July. Schedule planting so that a uniform quantity of celery is ready to harvest every week. Using transplants as opposed to direct seeding ensures uniform stands and faster maturing crops. Often, succession plantings are started every three weeks.

Harden off transplants by reducing water, not temperatures. Celery is a cool-season crop that produces best at temperatures of 60 to 80°F. Plants can withstand light frosts, but prolonged frosts below 28°F will cause damage. Plants may form seed stalks (bolt) if exposed to temperatures below 55°F for 7 days or longer.

## Harvesting

Once celery reaches marketable size, there is a narrow harvest window (about six to eight days) before a quality significantly reduces. Harvest celery by pulling the entire plant. Cut off the roots, chill quickly in cold water, and refrigerate in a plastic bag.

Store boxes in a cool place. Ideal storage conditions are near freezing and high humidity. Fresh market and processing celery are typically harvested mechanically. Fresh market celery is trimmed, sized, washed, and packed into cartons at on-farm packing sheds. Growers transport the packed celery to shippers where it is cooled and placed into cold storage for shipment.

## Fertilizing

Maintain the soil pH above 5.5 in muck soils and 6.5 in mineral soils.

**P<sub>2</sub>O<sub>5</sub>**: Maintain soil phosphorus at 45 to 80 ppm on mineral soils and 120 to 140 ppm on muck soils. If soil P is in this range, applying 50 to 70 pounds of P<sub>2</sub>O<sub>5</sub> per acre per year should be sufficient.

**K<sub>2</sub>O**: Maintain soil potassium at 85 to 115 ppm K on mineral soils with a CEC of 4, and at 100 to 130 ppm K on mineral soils with a CEC of 10. On muck soils maintain soil K at 210 to 260 ppm. If soil K is in this range, applying 290 to 406 pounds of K<sub>2</sub>O per acre per year should be sufficient.

**N**: Most celery crops will require applying 200 pounds of N per acre on mineral soils and 150 pounds of N per acre on muck soils. Since nitrogen demand for celery peaks later in the season, add most nitrogen as a side dressing. Banding fertilizer at transplanting can help when soil is cool. At transplanting, you can apply 40 pounds of N, up to 100 pounds of P<sub>2</sub>O<sub>5</sub> and up to 40 pounds of K<sub>2</sub>O per acre as a band application. You can apply the remaining N during the season. If additional P and K are needed above what is applied in band, broadcast it before transplanting.

Celery is responsive to boron (B). Apply 2 to 4 pounds of B per acre in banded or broadcast fertilizer to avoid stem cracking.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

# Disease Control

## Recommended Controls

### **Anthracnose of Celery - *Colletotrichum* Fungus**

Disease and symptom development are favored by periods of warm temperatures (>68 F) combined with high humidity. Symptoms include curled/cupped leaves, sporadic leaf margin discoloration, twisted petioles and small, oval lesions on petioles. Symptoms of anthracnose can be confused with those associated with aster yellows except that the affected foliage remains green.

**Cabrio EG® (pyraclostrobin)** 12-16 oz. per acre. See label. REI: 12-hour. PHI: 0-day.

**Merivon® (fluxapyroxad, pyraclostrobin)** 4-11 fl. oz. per acre. See label. REI: 12-hour. PHI: 1-day.

**Pristine 38WG® (boscalid, pyraclostrobin)** 10-15 oz. per acre. See label. REI: 12-hour. PHI: 0-day.

### **Bacterial Blight of Celery - *Pseudomonas* Bacteria**

Symptoms include leaf blight and extensive leaf death that requires additional trimming at harvest, resulting in yield loss. May be seedborne.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** See label. Several formulations of copper products (Badge®, Champ®, Cuprofix®, Copper-Count-N®, Kocide®, Nu-Cop®) are labeled for use and may slow the spread of bacterial blight. See label for directions. REI: see label. PHI: See label.

### **Crater Rot of Celery - *Rhizoctonia* Fungus**

**Catamaran® (potassium phosphite, chlorothalonil)** 4-5 pts. per acre. See label. REI: 12-hour. PHI: 0-day.

**chlorothalonil formulations (chlorothalonil)** See label. Several formulations of chlorothalonil (Bravo®, Equus®) are labeled at various rates. See product labels. REI: 12-hour. PHI: See label.

**Quadris Flowable® (azoxystrobin)** 0.4-0.8 fl. oz. per 1,000 row feet. See label. REI: 4-hour. PHI: 0-day.

**Quadris Opti® (azoxystrobin, chlorothalonil)** 2.4-3.7 pts. per acre. See label. REI: 12-hour. PHI: 7-day.

### **Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens**

Michigan State University research has found *Pythium* spp. causing damping-off of celery in greenhouses can result in poor field establishment. Conditions that favor rapid seedling germination may limit damping-off

severity. Avoid excessive irrigation and poorly drained soils. Good sanitation (including cleaning plug trays and plant containers that are reused) is critical to avoid damping-off.

**mefenoxam formulations (mefenoxam)** See label.

Apply preplant for greenhouse production. Several formulations of mefenoxam (Ridomil Gold SL®, Ridomil Gold GR®, Ultra Flourish®) are labeled for use. REI: 48-hour. PHI: See label.

**Uniform® (mefenoxam, azoxystrobin)** 0.34 fl. oz. per 1,000 ft. of row. Make one application per crop per season. REI: 0-hour. PHI: 0-day.

### **Early Blight of Celery - *Cercospora* Fungus**

Early blight (*Cercospora* leaf blight) symptoms include small, yellow spots that rapidly enlarge to tan or gray lesions. All above ground tissues of celery can become infected, resulting in losses of 50% or more when blighted stalks or leaves have to be removed at harvest.

**Cabrio EG® (pyraclostrobin)** 12-16 oz. per acre. See label. REI: 12-hour. PHI: 0-day.

**Catamaran® (potassium phosphite, chlorothalonil)** 4-5 pts. per acre. See label. REI: 12-hour. PHI: 0-day.

**chlorothalonil formulations (chlorothalonil)** See label.

Several formulations of chlorothalonil (Bravo®, Equus®) are labeled at various rates. See product labels. REI: 12-hour. PHI: See label.

**Flint Extra® (trifloxystrobin)** 2.5-2.9 fl. oz. per acre.

Maximum application volume: 30-gallons per acre. REI: 12-hour. PHI: 0-day.

**Fontelis® (penthiopyrad)** 14-24 fl. oz. per acre. See label. REI: 12-hour. PHI: 3-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** 4-5.8 fl. oz. per acre See label. REI: 12-hour. PHI: 7-day.

**Merivon® (fluxapyroxad, pyraclostrobin)** 4-11 fl. oz. per acre. See label. REI: 12-hour. PHI: 1-day.

**Pristine 38WG® (boscalid, pyraclostrobin)** 10-15 oz. per acre. See label. REI: 12-hour. PHI: 0-day.

**Propimax EC® (propiconazole)** 4 fl. oz. per acre. See label. REI: 12-hour. PHI: 14-day.

**Quadris Flowable® (azoxystrobin)** 0.4-0.8 fl. oz. per 1,000 row feet. See label. REI: 4-hour. PHI: 0-day.

**Quadris Opti® (azoxystrobin, chlorothalonil)** 2.4-3.7 pts. per acre. See label. REI: 12-hour. PHI: 7-day.

**Quilt® (azoxystrobin, propiconazole)** 14 fl. oz. per acre.

See label. REI: 12-hour. PHI: 14-day.

**Quilt Xcel® (azoxystrobin, propiconazole)** 14 fl. oz. per acre. See label. REI: 12-hour. PHI: 14-day.

**Tilt® (propiconazole)** 4 fl. oz. per acre. See label. REI: 12-hour. PHI: 14-day.

### **Late Blight of Celery - *Septoria* Fungus**

Late blight (*Septoria* leaf blight) include irregularly-shaped brown spots on leaves with pycnidia similar in appearance to grains of ground black pepper. Over time, these leaf spots expand and cause the entire leaf to die.

**Cabrio EG® (pyraclostrobin)** 12-16 oz. per acre. See label. REI: 12-hour. PHI: 0-day.

**Catamaran® (potassium phosphite, chlorothalonil)** 4-5 pts. per acre. See label. REI: 12-hour. PHI: 0-day.

**chlorothalonil formulations (chlorothalonil)** See label. Several formulations of chlorothalonil (Bravo®, Equus®) are labeled at various rates. See product labels. REI: 12-hour. PHI: See label.

**Flint Extra® (trifloxystrobin)** 2.5-2.9 fl. oz. per acre. Maximum application volume: 30-gallons per acre. REI: 12-hour. PHI: 0-day.

**Fontelis® (pentylopyrad)** 14-24 fl. oz. per acre. See label. REI: 12-hour. PHI: 3-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** 4-5.8 fl. oz. per acre See label. REI: 12-hour. PHI: 7-day.

**Merivon® (fluxapyroxad, pyraclostrobin)** 4-11 fl. oz. per acre. See label. REI: 12-hour. PHI: 1-day.

**Pristine 38WG® (boscalid, pyraclostrobin)** 10-15 oz. per acre. See label. REI: 12-hour. PHI: 0-day.

**Propimax EC® (propiconazole)** 4 fl. oz. per acre. See label. REI: 12-hour. PHI: 14-day.

**Quadris Flowable® (azoxystrobin)** 0.4-0.8 fl. oz. per 1,000 row feet. See label. REI: 4-hour. PHI: 0-day.

**Quadris Opti® (azoxystrobin, chlorothalonil)** 2.4-3.7 pts. per acre. See label. REI: 12-hour. PHI: 7-day.

**Quilt® (azoxystrobin, propiconazole)** 14 fl. oz. per acre. See label. REI: 12-hour. PHI: 14-day.

**Quilt Xcel® (azoxystrobin, propiconazole)** 14 fl. oz. per acre. See label. REI: 12-hour. PHI: 14-day.

**Reason 500SC® (fenamidone)** 8.2 fl. oz. per acre. See label. REI: 12-hour. PHI: 2-day.

**Tilt® (propiconazole)** 4 fl. oz. per acre. See label. REI: 12-hour. PHI: 14-day.

### **Rust of Multiple Crops - *Puccinia* Fungus**

**Flint Extra® (trifloxystrobin)** 2.5-2.9 fl. oz. per acre.

Maximum application volume: 30-gallons per acre. REI: 12-hour. PHI: 0-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** 4-5.8 fl. oz. per acre See label. REI: 12-hour. PHI: 7-day.

## **Weed Control**

### **Recommended Controls**

#### **Burndown**

**glyphosate formulations (glyphosate)** 1.5-2.25 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 2-3 qts. per acre. Use formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 1.3-2 qts. per acre. Apply to emerged perennials before planting, or after harvest in the fall. See label for suggested application volume and adjuvants and rates for specific weeds. REI: 4-hour. PHI: 14-day.

#### **Preemergence Broadleaf and Grass Weeds**

**Chateau SW® (flumioxazin)** 3 oz. per acre. Apply before transplanting or 3-7 days after transplanting for control of many annual broadleaf weeds and grasses. Do not tank mix with other pesticides. REI: 12-hour.

**Dual Magnum® (s-metolachlor)** 1-2 pts. per acre.

Indiana and Michigan only: applicators must have 24c label. Michigan label expires Dec 31, 2021. Apply before or immediately after transplanting. Will control annual grass and small-seeded broadleaf weeds and nutsedge. Use high rate on muck soils. Follow with 0.25-inch water within 7 days. REI: 24-hour. PHI: 62-day.

**trifluralin formulations (trifluralin)** 0.5-1 lb. a.i. per

acre. Use 4EC formulations at 1-2 pts. per acre. Use 10G formulations at 5-10 lbs. per acre. Apply and incorporate 1-2 inches before, during, or immediately after planting. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour.

**Zidua (pyroxasulfone)** 3.25 fl. oz. per acre of SC

formulation. 2.0 oz. per acre of WG formulation. Use only on muck soil with greater than 20% organic matter. Apply to transplanted celery 1-6 days after transplanting. REI: 12-hour.

#### **Postemergence Broadleaf and Grass Weeds**

**Caparol 4L® (prometryn)** 1-2 qts. per acre. Make 1 or 2 applications 2-6 weeks after transplanting but before

weeds are 2 inches tall. Do not exceed 2 qts. per acre per year. REI: 12-hour.

**Lorox DF® (linuron)** 1.5-2 lbs. per acre. Apply after transplants are established but before celery is 8 inches tall. Do not exceed 40 PSI pressure. Do not apply when temperatures exceed 85°F, and do not mix with wetting agents or other pesticides. REI: see label. PHI: 45-day.

### **Postemergence Grass Weeds**

**clethodim formulations (clethodim)** Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max® at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per season. REI: 24-hour. PHI: 30-day.

**Poast® (sethoxydim)** 1-1.5 pts. per acre. Apply to actively growing grasses. Include 1 qt. COC per acre. Do not exceed 3 pts. per acre per season. REI: 12-hour. PHI: 30-day.

## **Insect Control**

### **Recommended Controls**

#### **Aphids**

Over-treatment with permethrin may increase aphid problems.

Treat when more than 3% of plants are infested **or** there are more than 6 aphids per 100 sweeps.

Over-treatment with pyrethroids (IRAC 3A) may cause increased aphid problems.

**Actara® (thiamethoxam)** 1.5-3 oz. per acre. Allow 7 days between applications. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** 4.4-10.5 fl. oz. per acre. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 45-day.

**Assail 30SG® (acetamiprid)** 2-4 oz. per acre. Suppression only. Allow 7 days between applications. Do not exceed 20 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Belay 50WDG® (clothianidin)** Soil treatment: 4.8-6.4 oz. per acre. Foliar treatment: 1.6-2.1 oz. per acre. Allow 10 days between foliar applications. Do not exceed 6.4 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Beleaf 50SG® (fliconamid)** 2-2.8 oz. per acre. Allow 7 days between applications. Do not exceed 8.4 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Allow 7 days between applications. Do not exceed 21 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Durivo® (thiamethoxam, chlorantraniliprole)** 10-13 fl. oz. per acre. Apply as a soil treatment. Do not exceed 13 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Exirel® (cyantraniliprole)** 13.5-20.5 fl. oz. per acre. Use an effective adjuvant. Allow 5 days between applications. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Fulfill® (pyrethroid)** 2.75 oz. per acre. May require 5-7 days for aphid mortality. Allow 7 days between applications. Do not exceed 5.5 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**malathion formulations (malathion)** 1.5 pts. per acre for 5E and 57E formulations. Only 2 applications allowed PHI: 7-day.

**Movento® (spirotetramat)** 4-5 fl. oz. per acre. Must be tank-mixed with an adjuvant with spreading and penetrating properties. Allow 7 days between applications. Do not exceed 10.0 fl. oz. per acre per season. REI: 24-hour. PHI: 3-day.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-3.2 fl. oz. per acre. Allow 7 days between applications. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Nuprid 2SC® (imidacloprid)** 10-24 fl. oz. per acre. Apply as a soil treatment. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 45-day.

**Orthene 97 Soluble® (acephate)** 8-16 oz. per acre. Allow 3 days between applications of 8 oz. per acre, and 7 days between applications of over 16 oz. per acre. Do not exceed 34 oz. per acre per season. REI: 24-hour. PHI: 21-day.

**Perm-Up 3.2EC® (permethrin)** 2-8 fl. oz. per acre. Allow 7 days between applications. Do not exceed 40 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Sivanto 200SL® (flupyradifurone)** 10.5-12.0 fl. oz. per acre. Can be applied as a foliar spray or soil treatment. See label for application methods. REI: 4-hour. PHI: 1-day.

**Torac 15EC® (tolfenpyrad)** 17-21 fl. oz. per acre. Do not apply until 14 days after transplanting. Do not exceed 2 applications per crop per season. REI: 12-hour. PHI: 1-day.

**Verimark® (cyantraniliprole)** 6.75-13.5 fl. oz. per acre. Apply as a soil treatment. Do not exceed 30.6 fl. oz. per acre per season. REI: 4-hour. PHI: 0-day.

### **Carrot Weevil Beetle**

**Vydate L® (oxamyl)** 4 pts. per acre. Larvae only. Apply as a soil-directed spray. Start when eggs or larvae are first seen and repeat in 2 to 3 weeks. Allow 14 days between applications. Do not exceed 24 pts. per acre per season. REI: 48-hour. PHI: 21-day. *RUP*.

### **Caterpillars**

There are many caterpillar pests of celery, including cabbageworms, diamond back moth caterpillars, earworms, corn borers, cutworms, loopers, and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

Apply preventative treatments within 4 weeks of harvest. Treat as needed before that.

#### **Bacillus thuringiensis formulations for Lepidopterans**

(*Bacillus thuringiensis aizawai* strain ABTS-1857, *Bacillus thuringiensis aizawai* strain GC-91, *Bacillus thuringiensis kurstaki* strain ABTS-351, *Bacillus thuringiensis kurstaki* strain EVB-113-19, *Bacillus thuringiensis kurstaki* strain SA-11) Various Bt products are available for control of young caterpillars (Agree®, Biobit®, Dipel®, Javelin®, etc.) Different Bt subspecies have different control properties. Check labels for rates, timing of application and required safety equipment. REI: 4-hour. PHI: 0-day.

**Avaunt 30WDG® (indoxacarb)** 3.5 oz. per acre. For loopers and armyworms. Allow 3 days between applications. Do not exceed 56 oz. per acre per season. REI: 12-hour. PHI: 3-day.

**Baythroid XL® (beta-cyfluthrin)** 0.8-3.2 fl. oz. per acre. For cutworms, loopers and armyworms. Allow 7 days between applications. Do not exceed 12.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. For cutworms, loopers, and armyworms. Allow 7 days between applications. Do not exceed 21 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Confirm 2F® (tebufenozide)** 6-8 fl. oz. per acre. For loopers and armyworms. Allow 10 days between applications. Do not exceed 40 fl. oz. per acre per crop cycle or 120 fl. oz. per calendar year. REI: 4-hour. PHI: 7-day.

**Coragen® (chlorantraniliprole)** 3.5-5.0 fl. oz. per acre. Check label for specific caterpillars. Can be applied as a foliar spray or soil treatment. See label for application methods. Allow 3 days between foliar applications. Do not exceed 15.4 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Durivo® (thiamethoxam, chlorantraniliprole)** 10-13 fl. oz. per acre. Check label for specific caterpillars. Apply as a soil treatment. Do not exceed 13 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Entrust SC® (spinosad)** 1.5-8 fl. oz. per acre. Check label for specific caterpillars. Allow 4 days between applications. Do not exceed 29 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day. *OMRI-listed*.

**Exirel® (cyantraniliprole)** 7.0-17.0 oz. per acre. Check label for specific caterpillars. Allow 5 days between applications. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Intrepid 2F® (methoxyfenozide)** 4-10 oz. per acre. For loopers and armyworms. Early-season applications to young, small crops: 4-8 fl. oz. per acre. Mid- to late-season applications: 8-10 fl. oz. per acre. Do not exceed 64 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Lannate SP® (methomyl)** 0.25-1.0 lb. per acre For cutworms, loopers, and armyworms. Do not exceed 7 lbs. per acre per season. REI: 48-hour. PHI: 7-day. *RUP*.

**Movento® (spirotetramat)** 4-5 fl. oz. per acre. For diamondback moth caterpillars. Must be tank-mixed with an adjuvant with spreading and penetrating properties. Allow 7 days between applications. Do not exceed 10.0 fl. oz. per acre per season. REI: 24-hour. PHI: 3-day.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-3.2 fl. oz. per acre. For cutworms, loopers, and armyworms. Allow 7 days between applications. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Perm-Up 3.2EC® (permethrin)** 2-8 fl. oz. per acre. Check label for specific caterpillars. Allow 7 days between applications. Do not exceed 40 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Proclaim® (emamectin benzoate)** 2.4-4.8 oz. per acre. For loopers and armyworms. Allow 7 days between applications. Do not exceed 28.8 oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Radiant 1SC® (spinetoram)** 5-10 fl. oz. per acre. Check label for specific caterpillars. Allow 4 days between applications. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Sevin XLR Plus® (carbaryl)** 1-2 qts. per acre. For armyworms. Do not exceed 6 qts. per acre per season. REI: 12-hour. PHI: 14-day.

**Verimark® (cyantraniliprole)** 6.75-13.5 fl. oz. per acre. Apply as a soil treatment. Do not exceed 30.6 fl. oz. per acre per season. REI: 4-hour. PHI: 0-day.

### **Leafhoppers**

Treat when there are more than 14 leafhoppers per 100 sweeps.

Repeat as needed, depending on number of leafhoppers.

**Actara® (thiamethoxam)** 1.5-3 oz. per acre. Allow 7 days between applications. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** 4.4-10.5 fl. oz. per acre. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 45-day.

**Belay 50WDG® (clothianidin)** Soil treatment: 4.8-6.4 oz. per acre. Foliar treatment: 1.6-2.1 oz. per acre. Allow 10 days between foliar applications. Do not exceed 6.4 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Allow 7 days between applications. Do not exceed 21 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Durivo® (thiamethoxam, chlorantraniliprole)** 10-13 fl. oz. per acre. Apply as a soil treatment. Do not exceed 13 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Lannate SP® (methomyl)** 0.25-1.0 lb. per acre. Do not exceed 7 lbs. per acre per season. REI: 48-hour. PHI: 7-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-3.2 fl. oz. per acre. Allow 7 days between applications. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Nuprid 2SC® (imidacloprid)** 10-24 fl. oz. per acre. Apply as a soil treatment. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 45-day.

**Perm-Up 3.2EC® (permethrin)** 2-8 fl. oz. per acre. Allow 7 days between applications. Do not exceed 40 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Platinum 75SG® (thiamethoxam)** 1.66-3.67 oz. per acre. Apply as a soil treatment. Do not exceed 3.7 oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Scorpion 35SL® (dinotefuran)** 2.0-5.25 fl. oz. per acre. Soil treatment: 9-10.5 oz. per acre. Foliar treatment: 2-5.25 oz. per acre. Allow 7 days between applications. Do not exceed 21 fl. oz. per acre per season soil applied or 10.5 fl. oz. per acre per season foliar applied. REI: 12-hour. PHI: 21-day as foliar applied, 7-day as soil applied.

**Sevin XLR Plus® (carbaryl)** 0.5-2 qts. per acre. Do not exceed 6 qts. per acre per season. REI: 12-hour. PHI: 14-day.

**Sivanto 200SL® (flupyradifurone)** 7.0-10.5 fl. oz. per acre. Can be applied as a foliar spray or soil treatment. See label for application methods. REI: 4-hour. PHI: 1-day.

**Torac 15EC® (tolfenpyrad)** 14-21 fl. oz. per acre. Do not apply until 14 days after transplanting. Do not exceed 2 applications per crop per season. REI: 12-hour. PHI: 1-day.

**Venom 70SG® (dinotefuran)** Soil treatment: 5-6 oz. per acre. Foliar treatment: 1-3 oz. per acre. Allow 7 days between applications. Do not exceed 12 fl. oz. per acre per season soil applied or 6 fl. oz. per acre per season foliar applied. REI: 12-hour. PHI: 21-day as soil treatment, 7-day as foliar treatment.

### **Leafminers**

Treat as soon as visible mines appear and repeat every 7 days as needed.

**Actara® (thiamethoxam)** 1.5-3 oz. per acre. Allow 7 days between applications. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** 4.4-10.5 fl. oz. per acre. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 45-day.

**Agri-Mek SC® (abamectin)** 1.75-3.5 fl. oz. per acre. Use with a nonionic surfactant. Allow 7 days between applications. Do not exceed 10.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** 0.8-3.2 fl. oz. per acre. Allow 7 days between applications. Do not exceed 12.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Coragen® (chlorantraniliprole)** 5.0-7.5 fl. oz. per acre. Can be applied as a foliar spray or soil treatment. See label for application methods. Allow 3 days between foliar applications. Do not exceed 15.4 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Dimethoate 4EC® (dimethoate)** 1 pt. per acre. Allow 7 days between applications. Do not exceed 3 pts. per acre per season. REI: 48-hour. PHI: 7-day.

**Durivo® (thiamethoxam, chlorantraniliprole)** 10-13 fl. oz. per acre. Apply as a soil treatment. Do not exceed 13 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Entrust SC® (spinosad)** 6-10 fl. oz. per acre. Allow 4 days between applications. Do not exceed 29 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day. OMRI-listed.

**Exirel® (cyantraniliprole)** 13.5-20.5 fl. oz. per acre. Use an effective adjuvant. Allow 5 days between applications. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Platinum 75SG® (thiamethoxam)** 1.66-3.67 oz. per acre. Apply as a soil treatment. Do not exceed 3.7 oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Radiant 1SC® (spinetoram)** 5-10 fl. oz. per acre. Allow 4 days between applications. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Scorpion 35SL® (dinotefuran)** 2.0-5.25 fl. oz. per acre. Soil treatment: 9-10.5 oz. per acre. Foliar treatment: 2-5.25 oz. per acre. Allow 7 days between applications. Do not exceed 21 fl. oz. per acre per season soil applied or 10.5 fl. oz. per acre per season foliar applied. REI: 12-hour. PHI: 21-day as foliar applied, 7-day as soil applied.

**Trigard® (cyromazine)** 2.66 oz. per acre. Allow 7 days between applications. Do not exceed 6 applications per crop. REI: 12-hour. PHI: 7-day.

**Venom 70SG® (dinotefuran)** Soil treatment: 5-6 oz. per acre. Foliar treatment: 1-3 oz. per acre. Allow 7 days between applications. Do not exceed 12 fl. oz. per acre per season soil applied or 6 fl. oz. per acre per season foliar applied. REI: 12-hour. PHI: 21-day as soil treatment, 7-day as foliar treatment.

**Verimark® (cyantraniliprole)** 6.75-13.5 fl. oz. per acre. Apply as a soil treatment. Do not exceed 30.6 fl. oz. per acre per season. REI: 4-hour. PHI: 0-day.

### **Mites**

**Actara® (thiamethoxam)** 1.5-3 oz. per acre. Allow 7 days between applications. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** 4.4-10.5 fl. oz. per acre. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 45-day.

**Agri-Mek SC® (abamectin)** 1.75-3.5 fl. oz. per acre. Use with a nonionic surfactant. Allow 7 days between applications. Do not exceed 10.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day. RUP.

**Dimethoate 4EC® (dimethoate)** 1 pt. per acre. Allow 7 days between applications. Do not exceed 3 pts. per acre per season. REI: 48-hour. PHI: 7-day.

**malathion formulations (malathion)** 1.5 pts. per acre for 5E and 57E formulations. Only 2 applications allowed. PHI: 7-day.

**Oberon 2SC® (spiromesifen)** 7.0-8.5 fl. oz. per acre. For the treatment of Two-Spotted Spider Mites in Michigan only - applicators must have 24c label. Michigan label expires August 23, 2022. Allow 7 days between applications. Do not exceed 25.5 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Verimark® (cyantraniliprole)** 6.75-13.5 fl. oz. per acre. Apply as a soil treatment. Do not exceed 30.6 fl. oz. per acre per season. REI: 4-hour. PHI: 0-day.

### **Nematodes**

Plant nematode-free transplants to prevent serious losses. Root-knot, pin, needle, and root-lesion nematodes can reduce celery yields. If your fields have indeterminate root problems, test for nematodes. If the plant-parasitic nematodes are present above the economic thresholds, rotate crops or apply a nematicide.

Trained diagnostic service providers tally nematodes from each class within 100 cubic centimeters of soil, and assign a risk index to guide management.

**Telone II® (1,3-dichloropropene)** Muck soils: 25 gals. per acre. Mineral soils: 9-18 gals. per acre. Fumigate in the fall when soil temperatures at 6 inches are above 50 F. Inject fumigant to a soil depth of 8 inches and lightly seal the soil immediately after application. Use fumigants only as directed on the label. In some limited situations fumigants can be applied in the spring. Allow dissipation for 1 week for every 10 gals. per acre plus 1 more week. REI: see label. *RUP*.

**Vydate L® (oxamyl)** Preplant: 2 gals. per acre in 20 gals. of water in an 8- to 16-inch band. Incorporate to a depth of 4 inches. At planting: 0.5-1 gal. per acre in at least 100 gals. of water immediately after transplanting seedlings. After planting: 1 gal. per acre in at least 100 gals. of water as a foliar spray. Apply two sprays 3 weeks apart beginning 3 weeks after transplanting. Allow 14 days between applications. Do not exceed 3 gals. per acre per season. REI: 48-hour. PHI: 21-day. *RUP*.

### Slugs

**Deadline Bullets 4B® (metaldehyde)** 25 lbs. per acre. Apply between rows. Avoid contact with edible product. Allow 21 days between applications. Do not exceed 100 lbs. per acre per season. REI: 12-hour. PHI: 1-day.

### Tarnished Plant Bug

Treat if there are 2-4 tarnished plant bugs per 20 plants.

**Baythroid XL® (beta-cyfluthrin)** 0.8-3.2 fl. oz. per acre. Allow 7 days between applications. Do not exceed 12.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Beleaf 50SG® (flonicamid)** 2-2.8 oz. per acre. Allow 7 days between applications. Do not exceed 8.4 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-3.2 fl. oz. per acre. Allow 7 days between applications. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Sevin XLR Plus® (carbaryl)** 0.5-2 qts. per acre. Do not exceed 6 qts. per acre per season. REI: 12-hour. PHI: 14-day.

**Torac 15EC® (tolfenpyrad)** 17-21 fl. oz. per acre. Do not apply until 14 days after transplanting. Do not exceed 2 applications per crop per season. REI: 12-hour. PHI: 1-day.

### Thrips

**Exirel® (cyantraniliprole)** 13.5-20.5 fl. oz. per acre. Use an effective adjuvant. Allow 5 days between applications. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Radiant 1SC® (spinetoram)** 5-10 fl. oz. per acre. Allow 4 days between applications. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Torac 15EC® (tolfenpyrad)** 21 fl. oz. per acre. Do not apply until 14 days after transplanting. Do not exceed 2 applications per crop per season. REI: 12-hour. PHI: 1-day.

### Whiteflies

**Assail 30SG® (acetamiprid)** 2-4 oz. per acre. Suppression only. Allow 7 days between applications. Do not exceed 20 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Exirel® (cyantraniliprole)** 13.5-20.5 fl. oz. per acre. Use an effective adjuvant. Allow 5 days between applications. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Movento® (spirotetramat)** 4-5 fl. oz. per acre. Must be tank-mixed with an adjuvant with spreading and penetrating properties. Allow 7 days between applications. Do not exceed 10.0 fl. oz. per acre per season. REI: 24-hour. PHI: 3-day.

**Sivanto 200SL® (flupyradifurone)** 10.5-14.0 fl. oz. per acre. Can be applied as a foliar spray or soil treatment. See label for application methods. REI: 4-hour. PHI: 1-day.

# Cole Crops and Brassica Leafy Greens

## Spacing

**Broccoli:** Rows 3 feet apart. Plants 12 to 18 inches apart in row.

**Brussels sprouts:** Rows 3 feet apart. Plants 18 to 24 inches apart in row.

**Cabbage for Market:** Rows 2 to 3 feet apart. Plants 12 to 15 inches apart in row.

**Cabbage for Kraut:** Rows 3 feet apart. Plants 18 inches apart in row.

**Cauliflower:** Rows 3 feet apart. Plants 15 to 18 inches apart in row.

**Collards:** Rows 3 to 3.5 feet apart. Plants 18 to 24 inches apart in row. Seed 1 to 2 pounds per acre.

**Kale:** Rows 2 to 3 feet apart. Plants 8 to 16 inches apart in row. Seed 2 to 4 pounds per acre. Use denser plantings if harvesting small leaves for salad or braising mixes.

**Mustard:** Rows 1 to 1.5 feet apart. Plants 10 to 12 inches apart in row. Seed 3 to 5 pounds per acre. Use denser plantings if harvesting small leaves for salad or braising mixes.

**Turnip greens:** Rows 6 to 12 inches apart. Plants 1 to 4 inches apart in row.

Raised beds (6 inches high, 40 inches wide, with 2 rows 11 inches apart on beds) may be desirable under certain conditions.

## Fertilizing

**Lime:** To maintain a soil pH of 6.0 to 6.5.

### Preplant

#### *Cole crops (broccoli, cabbage, cauliflower, and Brussels sprouts)*

**N:** 120 pounds per acre if soil organic matter less than 3 percent, and 80 pounds per acre if soil organic matter greater than 3 percent. **P<sub>2</sub>O<sub>5</sub>:** 25 to 200 pounds per acre. **K<sub>2</sub>O:** 0 to 250 pounds per acre. Cole crops, particularly cauliflower, are responsive to B on low organic matter soils, sandy soils, or where the pH is greater than 7.0. If B is needed, apply 1 to 2 pounds B per acre broadcast. Soil test and/or perform plant analysis on the previous crop to be sure B is needed. High soil B can be detrimental to rotational crops such as sweet corn, peas, or beans.

### **Greens (collards, kale, and mustard)**

**N:** 60 pounds per acre. **P<sub>2</sub>O<sub>5</sub>:** 0 to 150 pounds per acre. **K<sub>2</sub>O:** 0 to 200 pounds per acre.

### **All crops**

Adjust recommendations according to soil type, previous management, and soil test results for your state. For transplants, set each plant with 1 cup (8 ounces) of starter solution. If the transplant flat receives a heavy fertilizer feeding just prior to setting, the starter solution can be eliminated.

### **Sidedress N**

#### *Cole Crops*

60 pounds N per acre, two to three weeks after setting the transplants and when rapid growth has begun. Eliminate sidedressing if following soybeans. If leaching is likely on sandy soils, apply an additional 30 pounds N as a sidedress. Avoid excessive N fertilization with broccoli as it can cause too rapid growth and a hollow flower stalk.

### **Greens**

30 pounds N per acre on soils with more than 3 percent organic matter and following soybeans, alfalfa, or a grass-legume hay crop. For greens on soils with less than 3 percent organic matter and following those crops, apply 45 pounds N per acre. For greens following corn, small grains, or a vegetable crop, apply 60 pounds N per acre.

## Harvesting

**Broccoli:** Harvesting is done by hand while the head is still compact and before the flowers open. The central heads should be dark blue or green and 4 to 6 inches across when mature. If harvesting too late or when the heads are over mature, woodiness in the stems will develop. Depending on your marketing requirements, the main head is cut with 8 to 10 inches of stem. Sometimes a second harvest of side shoots can be obtained. Broccoli for processing should be cut with less attached stem (6 to 7 inches) and with few or no leaves. Fresh market broccoli should be cut longer, with little trimming. Broccoli quality is based on the degree of compactness, leafiness, head trimness, damage, and freedom from insects and extraneous debris.

**Cauliflower:** When ready to harvest, the heads should be compact and clear white. The heads become discolored and develop an undesirable flavor when exposed to sunlight. The longest leaves are normally tied loosely

together over the head to "blanch" and prevent the head from being exposed to the sun. The desirable harvest size is a diameter of approximately 6 inches. Delaying harvest usually will not result in obtaining larger heads. Instead, consider proper cultivar selection and plant spacing. Cauliflower should be hand-harvested and cut with 1 to 2 whorls of leaves to protect the head.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### **Black Leg of Brassicas - *Phoma* Fungus**

Black leg is an important disease of broccoli, Brussels sprouts, cauliflower and turnip. Since oilseed rape is particularly susceptible to black leg, avoid planting crucifer crops close to oilseed rape. Hot water treatment may help to reduce seedborne pathogens.

**Crop rotation** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Use a 3-4 year crop rotation to non-cruciferous crops.

**Tillage** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Till in early spring or fall to destroy crop residue.

**Rovral 4F® (iprodione)** *Broccoli* Flowable formulations at 2 pts. per acre; dry formulations at 1.3 lbs. per acre. REI: 24-hour. PHI: 0-day.

#### **Black Rot of Brassicas - *Xanthomonas* Bacteria**

Hot water seed treatments help to eliminate the seedborne pathogen.

**Crop rotation** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Use a 3-4 year crop rotation to non-cruciferous crops.

**Use healthy, disease-free seed** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens*

**Variety selection** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Use varieties with partial resistance.

**Tillage** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Till in early spring or fall to destroy crop residue.

**Actigard® (acibenzolar-s-methyl)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 0.5-1.0 oz. per acre. Suppression only. Do not apply to stressed plants. REI: 12-hour. PHI: 7-day.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Various fixed copper products may slow the spread of black rot. REI: see label. PHI: see labels.

#### **Blight of Brassicas - *Rhizoctonia* Fungus**

**Blocker 10G® (pentachloronitrobenzene (PCNB))** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 5.15 lbs. per 1,000 feet of linear row. See label for other application methods and rates.

**Cabrio EG® (pyraclostrobin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 12-16 oz. per acre. REI: 12-hour. PHI: 3-day for collard, kale and mustard; 0-day for all other brassicas.

**Cabrio EG® (pyraclostrobin)** *Turnip greens* 8-12 oz. per acre. REI: 12-hour. PHI: 0-day.

#### **Bottom Rot of Cabbage - *Rhizoctonia* Fungus**

Bottom rot of cabbage is caused by *Rhizoctonia* species.

**Sanitation** *Cabbage* Clean and sanitize transplant trays, benches. Remove infected plants, leaves, and supports. Remove trash frequently. Disinfect tools frequently. Avoid working field under wet conditions.

**Endura® (boscalid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 6-9 oz. per acre. Suppression only for bottom rot and powdery mildew. REI: 12-hour. PHI: 14-day for collard, kale and mustard; 0-day for broccoli, Brussels sprouts, cabbage and cauliflower.

### **Club Root of Brassicas - *Plasmodiophora* Fungus**

Avoid poorly drained soils with a history of club root. Serious losses can be avoided by raising the pH to 7.2 -7.3.

**Crop rotation** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Use crop rotations of 5 years or more with a non-cruciferous crops.

**Use healthy, disease-free seed** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Use disease-free seed and transplants.

#### **Blocker 4F® (pentachloronitrobenzene (PCNB))**

*Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 3 pts. per acre. Use in transplant solution or banded application. REI: 12-hour.

#### **Blocker 10G® (pentachloronitrobenzene (PCNB))**

*Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 5.15 lbs. per 1,000 feet of linear row. See label for other application methods and rates.

**Omega 500F® (fluazinam)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 6.45 fl. oz. per 100 gals. of water. Apply 3.4 fl. oz. of solution to each plant applied as a transplant soil drench. REI: see label. PHI: 50-day for heading vegetables.

### **Damping-Off Seed and Seedling Rots**

#### **of Multiple Crops - Multiple Pathogens**

**Sanitation** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Clean and sanitize equipment, propagation trays/pots and greenhouse surfaces.

**phosphite and phosphorous acid formulations (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* REI: see label. PHI: 0-day.

### **Downy Mildew of Brassicas - *Hyaloperonospora* Oomycete**

**Variety selection** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Select crop varieties for competitiveness, disease resistance, and regional adaptability.

**Actigard® (acibenzolar-s-methyl)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 0.5-1.0 oz. per acre. Suppression only. Do not apply to stressed plants. REI: 12-hour. PHI: 7-day.

**azoxystrobin formulations (azoxystrobin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 6.2-15.4 fl. oz. per acre. Trade names include Quadris® and Satori®. REI: 4-hour. PHI: 0-day.

**chlorothalonil formulations (chlorothalonil)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* REI: 12-hour. PHI: 7-day.

**Forum 4.18SC® (dimethomorph)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 6 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Orondis Opti Premix® (oxathiapiprolin, chlorothalonil)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 1.75-2.5 pts. per acre. REI: 12-hour. PHI: 7-day.

**Orondis Ultra Premix® (oxathiapiprolin, mandipropamid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 5.5-8.0 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

**phosphite and phosphorous acid formulations (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* REI: see label. PHI: 0-day.

**Presidio® (fluopicolide)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 3-4 oz. per acre. REI: 12-hour. PHI: 2-day.

**Ranman 400SC® (cyazofamid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.75 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Reason 500SC® (fenamidone)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 5.5-8.2 fl. oz. per acre. REI: 12-hour. PHI: 2-day.

**Revus® (mandipropamid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 8 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

**Ridomil Gold Bravo SC® (mefenoxam, chlorothalonil)**

*Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 1.5 lbs. per acre. REI: 48-hour. PHI: 7-day.

**Zampro® (ametoctradin, dimethomorph)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 14 fl. oz. per acre. REI: 12-hour. PHI: 0-day.**Leaf Spot of Brassicas - Alternaria Fungus**

**Crop rotation** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Use a 3-4 year crop rotation to non-cruciferous crops.

**Use healthy, disease-free seed** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens*

**Tillage** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens*  
Till in early spring or fall to destroy crop residue.

**azoxystrobin formulations (azoxystrobin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 6.2-15.4 fl. oz. per acre. Trade names include **Quadris®** and **Satori®**. REI: 4-hour. PHI: 0-day.

**Cabrio EG® (pyraclostrobin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 12-16 oz. per acre. REI: 12-hour. PHI: 3-day for collard, kale, and mustard; 0-day for all other cole crops.

**Cabrio EG® (pyraclostrobin)** *Turnip greens* 8-12 oz. per acre. REI: 12-hour. PHI: 0-day.

**chlorothalonil formulations (chlorothalonil)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* REI: 12-hour. PHI: 7-day.

**Endura® (boscalid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 6-9 oz. per acre. Suppression only for bottom rot and powdery mildew. REI: 12-hour. PHI: 14-day for collard, kale and mustard; 0-day for broccoli, Brussels sprouts, cabbage and cauliflower.

**Fontelis® (penthiopyrad)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 14-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Inspire Super® (difenoconazole, cyprodinil)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Orondis Opti Premix® (oxathiapiprolin, chlorothalonil)**

*Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 1.75-2.5 pts. per acre. REI: 12-hour. PHI: 7-day.

**Quadris Top® (azoxystrobin, difenoconazole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 12-14 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

**Reason 500SC® (fenamidone)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 8.2 fl. oz. per acre. REI: 12-hour. PHI: 2-day.

**Ridomil Gold Bravo SC® (mefenoxam, chlorothalonil)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 1.5 lbs. per acre. REI: 48-hour. PHI: 7-day.

**Switch 62.5WG® (cyprodinil, fludioxonil)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 11-14 oz. per acre. REI: 12-hour. PHI: 7-day.

**Powdery Mildew of Brassicas - Erysiphe Fungus**

**Variety selection** *Brussels sprouts, Cabbage* Select crop varieties for competitiveness, disease resistance, and regional adaptability.

**azoxystrobin formulations (azoxystrobin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 6.2-15.4 fl. oz. per acre. Trade names include **Quadris®** and **Satori®**. REI: 4-hour. PHI: 0-day.

**Endura® (boscalid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 6-9 oz. per acre. Suppression only for bottom rot and powdery mildew. REI: 12-hour. PHI: 14-day for collard, kale and mustard; 0-day for broccoli, Brussels sprouts, cabbage and cauliflower.

**Fontelis (penthiopyrad)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 14-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Inspire Super® (difenoconazole, cyprodinil)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Microthiol Disperss® (sulfur)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 3-10 lbs. per acre. REI: 24-hour. PHI: 0-day. OMRI-listed.

**Procure 480SC® (triflumizole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 6-8 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

**Quadris Top® (azoxystrobin, difenoconazole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 12-14 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

### **Stem Rot of Cole Crops - Sclerotinia Fungus**

**Cabrio EG® (pyraclostrobin)** *Collards, Kale, Mustard greens* 12-16 oz. per acre. Suppression only. REI: 12-hour. PHI: 3-day.

**Endura® (boscalid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 6-9 oz. per acre. Suppression only for bottom rot and powdery mildew. REI: 12-hour. PHI: 14-day for collard, kale and mustard; 0-day for broccoli, Brussels sprouts, cabbage and cauliflower.

**Fontelis® (pentiopyrad)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards* 16 to 30 fl. oz. REI: 12-hour. PHI: 0-day.

### **White Rust of Brassicas - *Albugo* Fungus**

**azoxystrobin formulations (azoxystrobin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 6.2-15.4 fl. oz. per acre. Trade names include *Quadris®* and *Satori®*. REI: 4-hour. PHI: 0-day.

**Cabrio EG® (pyraclostrobin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Mustard greens* 12-16 oz. per acre. REI: 12-hour. PHI: 3-day for collard, kale, and mustard; 0-day for all other brassicas.

**Cabrio EG® (pyraclostrobin)** *Turnip greens* 8-16 oz. per acre. REI: 12-hour. PHI: 0-day.

**Reason 500SC® (fenamidone)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 8.2 fl. oz. per acre. REI: 12-hour. PHI: 2-day.

### **Yellows of Multiple Crops - *Fusarium* Fungus**

**Use healthy, disease-free seed** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens*

**Variety selection** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Use varieties with partial resistance.

## **Weed Control**

### **Recommended Controls**

#### **Burndown or Directed/Shielded Application**

##### **Broadleaves and Grasses**

**Gramoxone SL 2.0® (paraquat)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard* 2-4 pts. per acre. Not for Turnip greens. Include 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gallons of spray solution. Apply before seeding or transplanting, or after seeding but before crop emergence. REI: see label. *RUP*.

**glyphosate formulations (glyphosate)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens*. Not for Turnip greens. See product labels for rates, application volume, and adjuvants. Broadcast before seeding or transplanting, after seeding but before crop emergence, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. REI: 4-hour. PHI: 14-day.

#### **Preemergence Broadleaf and Grass Weeds**

**Command 3ME® (clomazone)** 0.67-1.3 pts. per acre. *Cabbage only*. Apply before seeding or transplanting or after seeding before crop emerges. Use low rate for seeded cabbage. May cause early stunting or discoloration of cabbage. REI: 12-hour. PHI: 45-day.

**Devinol DF-XT® (napropamide)** 2 lbs. per acre. *Broccoli, Brussels sprouts, Cabbage, Cauliflower. Not for collards, kale, kohlrabi, Mustard greens, or Turnip greens*. Apply and incorporate 1-2 inches before seeding or transplanting or apply after seeding and irrigate to wet soil 2-4 inches deep. After harvest or prior to planting succeeding crops, deep moldboard or disk plow. Do not seed alfalfa, small grains, sorghum, corn, or lettuce for 12 months after application. Most effective when combined with *Goal®*. REI: 24-hour.

**Dual Magnum® (s-metolachlor)** *Indiana, Michigan and Ohio only.* Uses vary by state. Applicator must have 24c label.

*Cabbage transplants in Indiana, Michigan, and Ohio only:* 0.5-1.3 pts. per acre. Apply before transplanting and do not incorporate, or apply within 48 hours after transplanting. Reduce risk of crop injury by applying after transplanting and by using a directed spray rather than spraying over the top of transplants. Do not exceed 1.3 pts. per acre or 1 application per crop per season. 60-day PHI.

*Broccoli, Brussels sprouts, and Cauliflower transplants in Indiana and Michigan only:* 0.5-1.3 pts. per acre. Apply to soil surface before transplanting or within 48 hours of transplanting. Do not tank-mix with Goal® for post-transplant application. 60-day PHI.

*Broccoli raab, Chinese cabbage (bok choy), Collards, Kale, Mizuna, Mustard greens, Mustard spinach, Rape greens, and Turnip greens in Indiana, Michigan, and Ohio only:* 0.67-1.3 pts. per acre. Apply after seeding before weeds or crop emerge, or apply broadcast after crops have 1-2 true leaves. Do not exceed 1.3 pts. per acre or 1 application per crop per season. 30-day PHI

REI: 24-hour.

#### **Prowl H2O® (pendimethalin) 1-2.1 pts. per acre.**

*Broccoli, Brussels sprouts, Cabbage, and Cauliflower only.* Apply to soil between rows 1-3 days after transplanting, or at 2-4 leaf stage after direct seeding. Spray contact with plants may cause crop stunting. REI: 24-hour. PHI: 60-day for broccoli; 70-day for Brussels sprouts, cabbage, and cauliflower.

#### **Satellite Hydrocap® (pendimethalin) 1-2.1 pts. per acre.**

*Broccoli, Brussels sprouts, Cabbage, and Cauliflower.* Apply pre- or posttransplanting broadcast, or directed between rows at the 2-4 leaf stage. Apply at 2-4 leaf stage of direct seeded plants. REI: 24-hour. PHI: 60-day for broccoli; 70-day for Brussels sprouts, cabbage, and cauliflower.

*Broccoli raab, Bok choy, Collards, Kale, Mizuna, Mustard greens, Mustard spinach, Rape greens, Turnip greens.* Apply as a broadcast spray at the 4-5 leaf stage of direct seeded or transplanted plants. Do not use roots from treated turnips for feed or food. REI: 24-hour. PHI: 21-day.

**trifluralin formulations (trifluralin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard, Turnip greens* 0.5-0.75 lb. a.i. per acre. Use 4EC formulations at 1-1.5 pts. per acre for seeded crops, up to 2 pts. per acre for transplanted crops. Use 10G formulations at 5-7.5 lbs. per acre for seeded crops, up to 10 lbs. per acre for transplanted crops. Apply before planting and incorporate 2-3 inches immediately. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour.

#### **Preemergence Broadleaf Weeds**

**Goal 2XL® or GoalTender® (oxyfluorfen)** *Broccoli, Cabbage, Cauliflower.* *Transplants only,* not for direct-seeded crops. Use 1-2 pts. per acre of Goal 2XL® or 0.5-1 pt. per acre of GoalTender®. Use lower rate on coarse-textured soils. Apply after preparing soil but before transplanting. Transplant within 7 days of application. REI: see label.

**Spartan 4F® (sulfentrazone)** 2.25-12 fl. oz. per acre.

Transplanted cabbage for processing only. Do not use on cabbage for fresh market or on direct seeded cabbage. Apply preemergence before transplanting as a broadcast or banded spray or band to row middles within 72 hours after transplanting. May be incorporated no deeper than 2 inches before transplanting. Do not use on soils classified as sand, with less than 1% organic matter. Controls pigweeds. REI: 12-hour.

**Spartan Charge® (carfentrazone, sulfentrazone)** 2.9-15.2 fl. oz. per acre. Transplanted cabbage only. Apply before transplanting, or band between rows within 72 hours after transplanting. May be incorporated no deeper than 2 inches before transplanting. Do not use on sandy soils with less than 1% organic matter. Has not been tested on all varieties. Refer to label for additional precautions. Maximum 15.2 fl. oz. per acre. REI: 12-hour.

#### **Preemergence Grass Weeds**

**Dacthal Flowable® or Dacthal W75® (DCPA)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard, Turnip greens.* Use 6-14 pts. per acre of flowable formulation or 6-14 lbs. per acre of 75W formulation. Apply at seeding or transplanting. May be incorporated. May be applied over top of transplants. REI: 12-hour.

**Herbicides for Cole Crops and Leafy Greens<sup>1</sup>**

Product (REI/PHI)	Common Name	Timing and Application Location Relative to Crop		Incorporated	Timing Relative to Weeds	Weed Groups Controlled	Crops								
		Postemergence — before transplanting	Postemergence — between rows only				Preemergence — before seeding	Postemergence — after seeding before emergence	Annual grasses	Small-seeded broadleaves	Broccoli	Brussels sprouts	Cabbage	Caiflower	Brassica greens
Aim EC <sup>®</sup> (12h/-)	carfentrazone	X			X	X								X	X
Command 3ME <sup>®</sup> (12h/45d)	clomazone	X	X			X								X	
Dacthal <sup>®</sup> (12h/-)	DCPA	X	X	X	X									X	X
Devrinol 50DF <sup>®</sup> (12h/-)	napropamide	X	X			Yes	X	X	X	X	X	X	X	X	X
Dual Magnum <sup>®</sup> (24h/21d)	s-metolachlor		X		X		X	X	X	X	X			X	X
Goal Tender <sup>®</sup> 4 SC (12h/-)	oxyfluorfen		X				X		X	X	X			X	X
Gramoxone <sup>®</sup> (12h to 24h/-)	paraquat	X	X		X			X	X	X	X			X	X
Poast <sup>®</sup> (12h/14-30d)	sethoxydim	X	X	X	X			X	X	X	X			X	X
Prefar 4E <sup>®</sup> (12h/-)	bensulide	X	X					X						X	X
Roundup <sup>®</sup> , others (12h/14d)	glyphosate	X	X	X	X			X	X	X	X			X	X
Satellite <sup>®</sup> Hydrocap 3.8 CS	pendimethalin		X	X	X	No	X	X	X	X	X			X	X
Select Max <sup>®</sup> , others (12h/14-30d)	clethodim	X	X	X	X			X	X	X	X			X	X
Spartan DF <sup>®</sup> (12h/1d)	sulfentrazone		X	X				X						X	
Spartan Charge <sup>®</sup> (12h/-)	sulfentrazone plus carfentrazone		X	X	X			X	X	X	X			X	
Stinger <sup>®</sup>	clopyralid	X	X	X	X									X	X
Treflan <sup>®</sup> , others (12h/-)	trifluralin	X		X		Yes	X	X	X	X	X	X	X	X	X

For effectiveness against specific weeds, see Relative Effectiveness of Herbicides for Vegetable Crops (page 68), and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbicides can cause serious crop injury and yield loss if not used properly.

**Prefar 4E® (bensulide)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard, Turnip greens* 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply before planting and incorporate 1-2 inches or apply after seeding before crop emerges and irrigate within 24 hours. REI: 12-hour.

### **Postemergence Broadleaf Weeds**

**Aim EC® (carfentrazone)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard, Turnip greens* Apply with hooded sprayers as a directed application between crop rows. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not allow spray to contact crop. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour.

**GoalTender® (oxyfluorfen)** *Broccoli, Cabbage, Cauliflower. Michigan only.* 4-8 fl. oz. per acre. Applicator must have 24c label (Michigan label expires April 16, 2024). Apply to well-established transplants at least 2 weeks in the field, or to direct-seeded plants with at least 4 true leaves. Do not add adjuvant. Do not exceed 16 fl. oz. pre- and postemergence. REI: see label. PHI: 35-day.

**Stinger® (clopypralid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard, Turnip greens* 4-8 fl. oz. per acre. Apply at any crop stage. Kills composite weeds, legumes, and nightshade. Do not exceed 2 applications and 8 fl. oz. per acre per year. REI: 12-hour. PHI: 30-day.

### **Postemergence Grass Weeds**

**clethodim formulations (clethodim)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi, Collards, Kale, Mustard, and Turnip greens.* Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max® at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per season. PHI: 14-day for Collards, Kale, Mustard, Turnip greens; 30-day for Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi.

**Poast® (sethoxydim)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard, Turnip greens* 1-1.5 pts. per acre. Include 1 qt. COC per acre. Spray on actively growing grass. Use high

rate on quackgrass. Do not exceed 2.5 pts. per acre per season for Turnip greens, or 3 pts. per acre per season for other crops. REI: 12-hour. PHI: 14-day for Turnip greens. 30-day for all others.

## **Insect Control**

### **Recommended Controls**

#### **Aphids**

**M-Pede® (potassium salts of fatty acids)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 1-2% volume. Must contact aphids to be effective. Works best in tank mix with other insecticide. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Actara® (thiamethoxam)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 1.5-3.0 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower, 7-day PHI for leafy greens.

**Admire Pro® (imidacloprid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Soil Application: 4.4-10.5 fl. oz. per acre. Do not exceed 10.5 fl. oz. per acre per crop. Foliar Application: 1.3 fl. oz. per acre. Do not exceed 6.5 fl. oz. per acre per crop. REI: 12-hour. PHI: 21-day for soil application, 7-day for foliar application.

**Assail 30SG® (acetamiprid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.0-5.3 oz. per acre. Do not exceed 20 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Beleaf 50SG® (flonicamid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.0-2.8 oz. per acre. Do not exceed 8.4 oz. per acre per season. REI: 12-hour. PHI: 0-day PHI.

**chlorpyrifos formulations (chlorpyrifos)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Use 4E formulations at 1-2 pts. per acre. Use 75WG formulations at 0.67-1.33 lbs. per acre. Cabbage aphid only. REI: see label. PHI: 21-day. RUP.

**dimethoate formulations (dimethoate)** *Broccoli, Cauliflower, Kale, Mustard greens* 0.5-1 pt. per acre. Use 0.5-1 pt. per acre for both 4E and 400 formulations. REI: see label. PHI: 7-day for heading cole crops, 14-day for leafy cole crops.

**Fulfill® (pymetrozine)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per crop per season. REI: 12-hour. PHI: 7-day PHI.

**Harvanta® (cyclaniliprole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 10.9-16.4 fl. oz. per acre. Use with adjuvant. Do not exceed 65.6 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Movento® (spirotetramat)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 3.2-4.0 fl. oz. per acre. Do not exceed 24 oz. per acre per season. REI: 12-hour. PHI: 1-day. RUP.

**Orthene 97® Soluble (acephate)** *Brussels sprouts, Cauliflower* 0.5-1.0 lb. per acre. Do not exceed 4 1/8 lbs. per acre per season. REI: 24-hour. PHI: 14-day.

**Platinum 75SG® (thiamethoxam)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 1.66-3.67 oz. per acre. Do not exceed 3.67 oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Sivanto Prime® (flupyradifurone)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 7-12 fl. oz. per acre. For foliar application. Do not exceed 28 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

## **Caterpillars**

### **Cabbage**

*Transplant to cupping:*

Diamondback Moth Caterpillars: 50% infested with >/= 5 larvae per plant.

Cabbageworm and Looper Caterpillars: 30% infested

*Cupping to early head:*

Diamondback Moth Caterpillars: 50% infested with >/= 5 larvae per plant.

Cabbageworm and Looper Caterpillars: 20% infested

*Early head to harvest:*

Diamondback Moth Caterpillars: 10% infested with >/= 1 larvae per plant.

Cabbageworm and Looper Caterpillars: 10% infested

### **Broccoli/Cauliflower**

*Seedbed:*

Diamondback Moth Caterpillars: 10% infested

Cabbageworm and Looper Caterpillars: 10% infested

*Transplant to first curd:*

Diamondback Moth Caterpillars: 40% infested

Cabbageworm and Looper Caterpillars: 20% infested

*First curd to harvest:*

Diamondback Moth Caterpillars: 10% infested

Cabbageworm and Looper Caterpillars: 10% infested

### **Bacillus thuringiensis formulations for Lepidopterans**

(*Bacillus thuringiensis aizawai* strain ABTS-1857, *Bacillus thuringiensis aizawai* strain GC-91, *Bacillus thuringiensis kurstaki* strain ABTS-351, *Bacillus thuringiensis kurstaki* strain EVB-113-19, *Bacillus thuringiensis kurstaki* strain SA-11) *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* See labels. Begin applications when worms are small. Using Bt will help conserve beneficial insects. REI: 4-hour. PHI: 0-day.

**Ambush® (permethrin)** *Broccoli, Cauliflower, Collards, Mustard greens* 3.2-12.8 fl. oz. per acre for broccoli and cabbage, and 3.2-6.4 fl. oz. per acre for Brussels sprouts and cauliflower. Do not exceed 64 fl. oz. per acre per season on cabbage. Do not exceed 51 fl. oz. per acre per season for all others. For use on collards in Illinois only at 3.2-9.6 fl. oz. per acre. REI: 12-hour. PHI: 1-day. RUP.

### **Asana XL® (esfenvalerate)**

*Broccoli, Cabbage, Cauliflower, Collards, Mustard greens* 2.9-9.6 fl. oz. per acre. Heading crops: Do not exceed 77.5 fl. oz. per acre per season. Collards and Mustard greens: Do not exceed 38.7 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**Avaunt 30WDG® (indoxacarb)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.5-3.5 fl. oz. per acre. Do not exceed 14 oz. per acre per season. REI: 12-hour. PHI: 3-day.

**Baythroid XL® (beta-cyfluthrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 0.8-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per crop. REI: 12-hour. PHI: 0-day. RUP.

**Brigade 2EC® (bifenthrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.1-6.4 fl. oz. per acre. Heading Crops: Do not exceed 32 fl. oz. per acre per season. Leafy Crops: Do not exceed 25.6 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**chlorpyrifos formulations (chlorpyrifos)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Use 4E formulations at 1-2 pts. per acre. Use 75WG formulations at 0.67-1.33 lbs. per acre. REI: 12-hour. PHI: 21-day.

**Confirm 2F® (tebufenozide)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 6.0-8.0 fl. oz. per acre. Do not exceed 40 fl. oz. per season. REI: 4-hour. PHI: 7-day.

**Coragen® (chlorantraniliprole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 3.5-7.5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. REI: 4-hour. PHI: 3-day.

**Entrust SC® (spinosad)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 1.5-6.0 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. Observe resistance management restrictions. REI: 4-hour. PHI: 1-day. OMRI-listed.

**Exirel® (cyantraniliprole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 7-17 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per crop. REI: 12-hour. PHI: 1-day.

**Harvanta® (cyclaniliprole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 10.9-16.4 fl. oz. per acre. Do not apply more than twice within a generation or two successive generations. Do not exceed 65.6 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Intrepid 2F® (methoxyfenozide)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 4-10 fl. oz. per acre. Do not exceed 64 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 14-day. RUP.

**Orthene 97® Soluble (acephate)** *Brussels sprouts, Cauliflower* 1 lb. per acre. Do not exceed 4 1/8 lbs. per acre per season. REI: 24-hour. PHI: 14-day.

**Permethrin 3.2EC® (permethrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kohlrabi, Turnip greens* 2.8 fl. oz. per acre. 2-4 oz. per acre for broccoli, Brussels sprouts, cauliflower and kohlrabi. 2-8 oz. per acre for cabbage. 2-4 oz. per acre for collards in Indiana only. Do not exceed 32 fl. oz. per acre per season for broccoli, Brussels sprouts, cauliflower collards, kohlrabi, and Turnip greens, or 40 oz. per acre per season for cabbage. REI: 12-hour. PHI: 1-day. RUP.

**Proclaim® (emamectin benzoate)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.4-4.8 fl. oz. per acre. Do not exceed 28.8 oz. per acre per season. REI: 12-hour. PHI: 7-day for heading cole crops, 14-day for leafy cole crops. RUP.

**Radiant 1SC® (spinetoram)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Rimon 0.83EC® (novaluron)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Sevin XLR Plus® (carbaryl)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 1-2 qts. per acre. Do not exceed 6 qt. per acre per crop. REI: 12-hour. PHI: 3-day for heading cole crops, 14-day for leafy cole crops.

*OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.*

**Warrior II® (lambda-cyhalothrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 0.96-1.92 fl. oz. per acre. Do not exceed 15.36 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. RUP.

### Flea Beetles

**Actara® (thiamethoxam)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 1.5-3 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 0-day for broccoli, Brussels sprouts, cabbage, and cauliflower, 7-day for leafy greens.

**Ambush® (permethrin)** *Cabbage* 6.4-12.8 fl. oz. per acre. Do not exceed 64 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. RUP.

**Asana XL® (esfenvalerate)** *Broccoli, Cabbage, Cauliflower, Collards, Mustard greens* 5.8-9.6 fl. oz. per acre. Heading crops: Do not exceed 77.5 fl. oz. per acre per season. Collards and Mustard greens: Do not exceed 38.7 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day for heading crops, 7-day for collards and Mustard greens. RUP.

**Baythroid XL® (beta-cyfluthrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.4-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per crop. REI: 12-hour. RUP.

**Belay® (clothianidin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Soil Applications: 9-12 fl. oz. per acre. Foliar Applications: 3-4 fl. oz. per acre. REI: 12-hour. PHI: 21-day for soil application, 7-day for foliar application.

**Brigade 2EC® (bifenthrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season for heading crops. Do not exceed 25.6 fl. oz. per acre per season for leafy crops. REI: 12-hour. PHI: 7-day. RUP.

**chlorpyrifos formulations (chlorpyrifos)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Use 4E formulations at 1-2 pts. per acre. Use 75WG formulations at 0.67-1.33 lbs. per acre. REI: see label. PHI: 21-day. RUP.

**Exirel® (cyantraniliprole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 13.5-20 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per crop. REI: 12-hour. PHI: 1-day.

**Harvanta® (cyclaniliprole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 10.9-16.4 fl. oz. per acre. Do not exceed 65.6 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Kryocide 96D® (cryolite)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards* 8-16 lbs. per acre. Do not exceed 96 lbs. per acre per season. REI: 12-hour. PHI: 7-day for broccoli, Brussels sprouts, and cauliflower. 14-day for cabbage and collards.

**Mustang Maxx® (zeta-cypermethrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. RUP.

**Permethrin 3.2EC® (permethrin)** *Cabbage* 4-8 fl. oz. per acre. Do not exceed 16 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. RUP.

**Platinum 75SG® (thiamethoxam)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 1.66-3.67 oz. per acre as a soil application. Do not exceed 3.67 oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Prokil Cryolite 50D® (cryolite)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards* 15-30.5 lbs. per acre. Do not exceed 184 lbs. per acre per season. REI: 12-hour. PHI: 7-day for broccoli, Brussels sprouts, and cauliflower, 14-day for cabbage and collards.

**Sevin XLR Plus® (carbaryl)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 05.-1 qt. per acre. Do not exceed 6 qts. per acre per crop. REI: 12-hour. PHI: 3-day for heading cole crops, 14-day for leafy cole crops.

**Warrior II® (lambda-cyhalothrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 1.28-1.92 fl. oz. per acre. Do not exceed 15.36 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. RUP.

## Leafminers

**M-Pede® (potassium salts of fatty acids)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 1-2% by volume. Works best in tank mix with other insecticide. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Entrust SC® (spinosad)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 4-10 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per year. REI: 4-hour. PHI: 1-day. OMRI-listed.

**Exirel® (cyantraniliprole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 13.5-20 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per crop. REI: 12-hour. PHI: 1-day.

**Harvanta® (cyclaniliprole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 10.9-16.4 fl. oz. per acre. Do not exceed 65.6 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. RUP.

**Radiant 1SC® (spinetoram)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 6-10 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day.

**Rimon 0.83EC® (novaluron)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Trigard® (cyromazine)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.66 oz. per acre. Do not exceed 6 applications per season. REI: 12-hour. PHI: 7-day.

**Venom 70SG® (dinotefuran)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Soil applications: 5-7.5 oz. per acre. Do not exceed 12 oz. per acre per season. Foliar applications: 1-4 oz. per acre. Do not exceed 6 oz. per acre per season. REI: 12-hour. PHI: 1-day.

## Seed and Root Maggots

**Capture LFR® (bifenthrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Can be used banded at-plant, pre-plant, or incorporated shortly after planting. See label. REI: 12-hour. RUP.

**chlorpyrifos formulations (chlorpyrifos)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Mustard greens* Use 4E formulations at 1.6-2.75 fl. oz. per 1000 ft. of row (max rate 2.4 fl. oz. for Cauliflower). Use 75WG formulations at 1.1-1.8 fl. oz. per 1000 linear ft. of row (max rate 1.6 fl. oz. for Cauliflower). Apply as a water-based spray directed at the base of plants immediately after setting in the field. Use minimum of 40 gallons of total spray per acre. Do not apply as foliage application. Do not exceed one application per acre per season. REI: see label. PHI: 30-day. RUP.

**Diazinon AG500® (diazinon)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 2-3 qts. per acre for pre-plant broadcast application using 200-300 gallons of spray mix per acre. 4-8 fl. oz. per acre in 50 gals. of water for drench application at planting. Make drench application at the rate of 0.5-1 cup per plants, either by hand or tractor mounted sprayer with drop nozzles to direct spray to base of plants. Water treatments may reduce stands due to plants stress at time of transplanting. Cabbage maggot exhibit resistance to diazinon. PHI: 4-day. RUP.

## Slugs

**Sluggo 1B® (iron phosphate)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 20-44 lbs. per acre, or at 05.-1 lb. per square ft. Prevent infestation by scattering bait products to the soil surface around the perimeter of the planting. Make a rescue treatment by scattering the bait products on the soil as a band between rows. REI: 0-hour. PHI: 0-day. OMRI-listed.

**Deadline M-Ps® (metaldehyde)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 25 lbs. per acre. REI: 12. PHI: 0-day.

## Stink Bugs

**Azera® (azadirachtin, pyrethrins)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 16-56 fl. oz. per acre. Use lower rates for nymphs. Use 48 fl. oz. per acre for adults. Use higher rates (56 fl. oz. per

acre) when pest pressure is extreme or plant canopy is dense. Do not exceed 10 applications per season. Do not reapply within 3 days except under extreme pest pressure. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Baythroid XL® (beta-cyfluthrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.4-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per crop. REI: 12-hour. PHI: 0-day. RUP.

**Belay® (clothianidin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Soil applications: 9-12 fl. oz. per acre. Foliar applications: 3-4 fl. oz. per acre. REI: 12-hour. PHI: 21-day for soil applications, 7-day for foliar applications.

**Brigade 2EC® (bifenthrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season for heading crops. Do not exceed 25.6 fl. oz. per acre per season for leafy crops. REI: 12-hour. PHI: 7-day. RUP.

**Harvanta® (cyclaniliprole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 10.9-16.4 fl. oz. per acre. For suppression of nymphs only. Do not exceed 65.6 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**malathion formulations (malathion)** *Collards* 1.5 pts. per acre. Harlequin Bugs only. Use 5EC formulations at 1.5 pts. per acre. Use 57EC formulations at 1 pts. per acre. PHI: 7-day.

**Mustang Maxx® (zeta-cypermethrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 3.2-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**Rimon 0.83EC® (novaluron)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 12 fl. oz. per acre. Do not exceed 24 oz. or 2 applications per acre per season. REI: 12-hour. PHI: 7-day.

**Sevin XLR Plus® (carbaryl)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 0.5-2 qts. per acre. Use low rates for Harlequin bugs. Use higher rates for other stink bugs. Do not exceed 6 qts. per acre per crop. REI: 12-hour. PHI: 3-day for heading cole crops, 14-day for leafy cole crops.

**Venom 70SG® (dinotefuran)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 1-4 oz. per acre. Do not exceed 6 oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Warrior II® (lambda-cyhalothrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Kohlrabi* 1.28-1.92 fl. oz. per acre. Do not exceed 15.36 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. RUP.

### **Swede Midge**

Swede midge is most attracted to heading cole crops (broccoli, cauliflower, cabbage, and Brussels sprouts). Leafy crops can become twisted and yield can be reduced. Some products that control flea beetles and caterpillars in cole crop work well on Swede midge, but may not have Swede midge explicitly on their label. Take advantage of this implied rotation to prevent resistance if your state does not require 2(ee) labels for specific pests. Products include Admire Pro (IRAC 4A), Coragen (IRAC 28), Exirel (IRAC 28), Lorsban (IRAC 1B), Orthene (IRAC 1B), Verimark (IRAC 28), and Warrior II (IRAC 3A).

**Crop rotation** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Rotate away from cole crops for three years. Do not use brassica cover crops between cole crop plantings. Rotate between crop families to reduce pest and disease inoculum buildup and weeds favored by the management of certain crops.

**Optimize weed control** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Control brassica weeds. Use to minimize shared pests and diseases

**Sanitation** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Destroy postharvest trash promptly. Remove infected plants, leaves, and supports such as plant stakes that can harbor disease to reduce disease spread. Remove trash frequently. Disinfect tools frequently. Avoid working field under wet conditions.

**Assail 30SG® (acetamiprid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2-5.3 oz. per acre for leafy crops, 2-4 oz. per acre for heading crops. Do not exceed 20 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Movento® (spirotetramat)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day.

### Thrips

**Variety selection** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* Varieties tolerant of thrips include Bantly, Bravo, Brutus, King Cole, Little Rock, Manrico, Rio Granda, Rio Verde, Ruby Perfection, Starski, Stonar, SuperKraut, Titanic 90, Zerlina, and others. Select crop varieties for competitiveness, disease resistance, and regional adaptability.

**Actara® (thiamethoxam)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 3-5.5 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 0-day for broccoli, Brussels sprouts, cabbage, and cauliflower, 7-day for leafy greens.

**Admire Pro® (imidacloprid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 4.4-10.5 fl. oz. per acre. Soil application. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day.

**Ambush® (permethrin)** *Broccoli, Brussels sprouts, Cauliflower* 3.2-6.4 fl. oz. per acre. Do not exceed 51 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**Assail 30SG® (acetamiprid)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 4-5.3 fl. oz. per acre for leafy crops, 4 oz. per acre for heading crops. Do not exceed 20 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Baythroid XL® (beta-cyfluthrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 0.8-1.6 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per crop. REI: 12-hour. RUP.

**Brigade 2EC® (bifenthrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season for heading crops. Do not exceed 25.6 fl. oz. per acre per season for leafy crops. REI: 12-hour. PHI: 7-day. RUP.

**Entrust SC® (spinosad)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 4-10 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day. OMRI-listed.

**Exirel® (cyantraniliprole)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 13.5-20 fl. oz. per acre. Do not exceed 61 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. RUP.

**Platinum 75SG® (thiamethoxam)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens, Turnip greens* 1.66-3.67 oz. per acre. Do not exceed 3.67 fl. oz. per acre. REI: 12-hour. PHI: 30-day.

**Radiant 1SC® (spinetoram)** *Broccoli, Brussels sprouts, Cabbage, Cauliflower, Collards, Kale, Kohlrabi, Mustard greens* 6-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

# Cucurbit Crops

## Cucurbit Crops — Cantaloupe, Cucumber, Squash, Pumpkin and Watermelon

### Types and Varieties

#### Cantaloupe

The most commonly cultivated melon is cantaloupe. Cantaloupes grown in the Midwest are primarily eastern types. Typical varieties include Athena and Aphrodite. Cantaloupes are warm-season crops that achieve prime quality when grown under warm, sunny conditions. Cool, cloudy weather results in melons with inferior quality. Melons prefer sandy and sandy loam soils. Production on plastic mulch and light soils produces an early crop that commands a premium price.

Melon types with distinctive fruit attributes are referred to as specialty melons. Common specialty melons include honeydew, charentais, galia, ananas, Persian, crenshaw, canary and Asian melon. These melons with unique fruit characteristics attract consumers at local food markets. Some specialty melons (such as galia and ananas) are bred in dry conditions. Their skins tend to crack with excessive water. Greenhouse or high tunnel environments are more suitable for growing these melons in the Midwest.

#### Cucumber

Several types of cucumbers are grown in the Midwest.

Fresh market slicing cucumbers have thick, dark skin and a few large spines. They are commonly grown in the field with no support.

European greenhouse cucumbers are long with thin skin, no spines, no seeds, and are grown on trellises in greenhouses.

Beit alpha cucumber types are shorter but also have thin skin with no spines, and may be grown in the field or in protected structures.

Pickling cucumbers are short with thin skins and large spines. They are adapted for field production. Pickling cucumbers can also be marketed for fresh use.

Gynoecious cucumber varieties produce mainly female flowers and, unless they are also parthenocarpic, require a pollinizer variety for good fruit set. Pollenizers are usually included when you buy gynoecious seed.

Parthenocarpic varieties will set fruit without pollination and no seeds will develop. Parthenocarpic varieties produce seeds if they get pollinated.

#### Watermelon

Watermelons are either seedless or seeded. Seedless watermelons are triploid. They produce fruit that has few if any true seeds. For seedless watermelons to set fruit, growers must plant diploid watermelons (non-edible pollenizer plants or seeded watermelons) next to the triploid plants. The general rule is to plant a pollinizer plant for every two to four triploid plants.

Watermelons produce a wide range of fruit sizes. Seeded watermelons generally have larger fruit (more than 20 pounds) than seedless types. Royal Sweet is a widely grown seeded watermelon variety that produces oblong melons that weigh 20 to 24 pounds.

Seedless watermelons typically are more than 12 pounds. They are sold in cardboard bins in quantities of 60, 45, 36 or 30. Excursion is a variety that produces relatively large fruit that are primarily 36-count. Wayfarer is a variety that produces relatively smaller fruit that are mainly 60-count. Mini or personal-size watermelons are less than 10 pounds and include varieties such as Extazy and Ocelott.

Watermelons differ in rind patterns and fruit shapes. Most watermelons have striped patterns on a dark or light green background. However, some varieties (Sweet Gem and Wayfarer) do not have stripes, but rather a pure dark green rind. A unique rind pattern called moon and star has golden-yellow spots on a deep green background. Seed companies have successfully bred both seedless and seeded watermelons with the moon and star patterns. The shapes of most large watermelons are blocky or oblong, while mini watermelons tend to be round.

Although watermelons with red flesh are most familiar, yellow, orange and white-fleshed varieties are available. Varieties include Orange Crisp (orange, seedless), Amarillo (yellow, seedless) and Cream of Saskatchewan (white, seeded).

#### Cantaloupe or Muskmelon?

Both cantaloupe and muskmelon are acceptable names for fruit from the vines known to scientists as *Cucumis melo* subsp. *Melo* var. *cantalupensis*. In this guide, we use cantaloupe to correspond to USDA standards, which use this term.

## Cantaloupe, Cucumber and Watermelon

### Spacing

**Cantaloupes:** Rows 5 to 7 feet apart. Plants 3 to 5 feet apart in row. 1 to 2 plants per hill. Plastic mulch is recommended. Clear mulch is suggested only for earliest plantings in northern areas.

**Watermelons:** Rows 6 to 12 feet apart. Plants 3 to 6 feet apart in row. One plant per hill. Plastic mulch is recommended for all transplanted watermelons.

**Mini- or “personal” watermelons:** Rows 6 to 10 feet apart. Plants 1.5 to 2 feet apart in row to allow 12 to 15 square feet per plant.

**Cucumbers for fresh market:** Rows 4 to 6 feet apart. Plants 15 to 18 inches apart in row.

**Pickles (machine harvest):** Rows 18 to 20 inches apart. Plants 5 to 7 inches apart in row.

All cucumbers should be planted after the danger of frost is past because they are not frost-tolerant. For proper germination, soil temperature must be above 60°F. Planting too early (when the soil is too cold and wet) results in poor seedling emergence.

### Fertilizing

**Lime:** To maintain a soil pH of 6.0 to 6.5. Cantaloupe is particularly sensitive to low soil pH and should be limed to 6.3 to 6.8. If your soil test indicates less than 70 ppm magnesium, use dolomitic limestone, or apply 50 pounds per acre Mg broadcast preplant incorporated.

**Preplant:** N: 40 to 60 pounds per acre. P2O5: 0 to 150 pounds per acre. K2O: 0 to 200 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. For transplants, a starter solution at the rate of 1 cup (8 ounces) per plant is recommended. If the transplant flat receives a heavy fertilizer feeding just prior to setting, the starter solution can be eliminated.

**Sidedress N:** Apply 45 pounds N per acre in a band to either side of the row when plants are rapidly vining. For direct seeded watermelon, the preplant N application can be replaced by an early sidedressing of 40 pounds N per acre when plants show the first set of true leaves followed by the 45 pounds N rate at the rapid vining stage of growth. If heavy rains occur in June, 30 pounds N per acre should be applied through the irrigation system at fruit set (late June to early July).

For cantaloupes and cucumbers grown on plastic mulch, the N rate can be reduced because N losses from leaching are greatly reduced. For this culture system, apply 50 pounds N per acre broadcast preplant over the row just

prior to laying the plastic. Sidedress 30 pounds N per acre on either side of the plastic at vining when plant roots have reached the edge of the plastic (mid-June). If you are using trickle irrigation, apply the 50 pounds N per acre preplant and apply 0.5 to 1 pound N per acre daily, or 3 to 6 pounds N weekly through the trickle system until fruit are about 2 inches in diameter.

### Irrigation

**Cucumbers:** Maximum yields and fruit quality result only if plants receive adequate and timely moisture. Depending on your soil type, obtaining high-quality cucumbers requires approximately 1 to 2 inches of water per week. An irregular water supply, particularly during blossoming and fruit development, can affect fruit quality detrimentally and result in increased nubbins or hooked fruit.

**Cantaloupes:** Cantaloupes are moderately deep rooted and require adequate soil moisture with good drainage. Natural rainfall may not be adequate, so supplemental irrigation may be required, particularly in the early stages of growth. When irrigating, irrigate the soil in the effective root zone to field capacity. A good, steady moisture supply is critical for good melon production. After melons have attained a good size, it is best to reduce irrigation. Reduced irrigation at this time can, in some cases, increase the mature fruit's sugar content. Excessive moisture during fruit ripening can result in poor quality.

**Watermelons:** Watermelons are deep-rooted plants, so natural rainfall often is adequate, and irrigation may not be cost effective on heavier soils. Adequate soil moisture in the early growth stages will help ensure vigorous growth. Soil moisture also is critical during blossoming and fruit development.

### Harvesting

**Cucumbers:** Unless a once-over mechanical harvester is used, cucumbers should be harvested at two- to four- day intervals to prevent losses from oversized and over-mature fruit. Desired harvest sizes range from 5 to 8 inches long and 1.5 to 2 inches in diameter for fresh market slicing types. If growing for processors, be sure to understand the specific terms of their contracts at the beginning of the growing season. Prices received are related to the quantity of fruit within specific size ranges as established by either USDA guidelines or by the processor.

**Melons:** During ripening, eastern type cantaloupes develop an identifiable abscission zone and form tan-colored netting. Harvest index is at three-quarter or full-slip stage. The fruit do not keep well in the field when ripe. Harvest every one to three days.

Cantaloupe varieties with long shelf life (such as Infinite Gold and Durawest) were tested in the Midwest. Long shelf life varieties have delayed abscission compared to normal eastern type cantaloupes. They either stay in green or have a continuous color change. Color and abscission are not used as harvest indices for long shelf life varieties. Indicators of the optimal ripeness are when there are a few vertical cracks on the peduncle but the fruit has not slipped yet. Long shelf life varieties can hold longer in the field, allowing growers to harvest two or three times.

Honeydew, crenshaw and canary melons do not develop netting on the skin and do not form abscission zones during ripening. Color is the primary harvest index.

**Watermelons:** Harvesting watermelons at the correct stage of maturity is critical and difficult. While each cultivar is different, maturity can be determined in several ways, including ground spots changing from white to yellow, browning of tendrils nearest the fruit, and a hollow or dull sound when "thumped." Watermelons should be cut from the plant to avoid vine damage and prevent stem-end rot. Leave 1 to 2 inches of stem attached.

## **Summer Squash and Pumpkin**

**Summer Squash:** Common summer squash types include zucchini, yellow straightneck and yellow crookneck. Many specialty types also perform well, including golden zucchini, Middle-Eastern types, patty pan, and cocozelle.

**Winter Squash:** Common winter squash types include acorn, buttercup, butternut, hubbard and spaghetti. Japanese types kuri and kabocha are also grown.

**Pumpkin:** Pumpkins grown for ornamental display or carving range from less than a pound to 30 pounds or more. For giant pumpkins, squash varieties such as Atlantic Giant or Prize Winner are used. Varieties with hull-less or "naked" seed are favored as a source of seeds for eating. Many specialty pumpkins are also edible winter squash, such as fairytale and Cinderella pumpkins. Most of the "pie" pumpkins sold to consumers are used for decorating, but some varieties are still used for home baking. Pumpkins that are processed into pie filling and other products are largely grown under contract to processors, and the varieties are more like winter squash than jack-o-lantern pumpkins.

## **Spacing and Seeding**

**Bush Types:** Rows 4-6 feet apart. Plant 18-24 inches apart in row. Seed: 4-6 pounds per acre.

**Vining Types:** Rows 6-8 feet apart. Plant 2-5 feet apart in row. Seed: 2-3 pounds per acre.

## **Fertilizing**

**Lime:** To maintain a soil pH of 6.0-6.8.

**Preplant:** N: 50 pounds per acre; P2O5: 0-150 pounds per acre; K2O: 0-200 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. For summer squash transplants, a starter solution at a rate of 1 cup (8 ounces) per plant is recommended. If the transplant flat receives a heavy fertilizer feeding just prior to setting, the starter solution can be eliminated.

**Sidedress N:** For soils with more than 3 percent organic matter and following soybeans, alfalfa, or a grass-legume hay crop, no N is needed. For soils with less than 3 percent organic matter with the same rotation or a rotation of corn, rye, oats, wheat, or a vegetable crop, apply 30-40 pounds N per acre when the vines begin to run. For sandy soils, the preplant N application can be replaced by an early sidedressing of 40 pounds N per acre when the plants show the first set of true leaves. Apply the second sidedressing of 45 pounds N per acre at onset of rapid vining.

For crops grown from transplants on plastic mulch, N losses from leaching are greatly reduced. For this culture system, apply 50 pounds N per acre broadcast preplant over the row just before laying the plastic. If sidedress N is recommended (see above), apply up to 30 pounds N per acre on either side of the plastic at vining when the plant roots have reached the edge of the plastic. If you are using trickle irrigation, apply the 50 pounds N per acre preplant, and apply 0.5-1 pound N per acre daily, or 3-6 pounds N weekly through the trickle system if additional N is needed.

## **Pesticide Use in Greenhouses**

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## **Disease Control**

### **Recommended Controls**

#### **Angular Leaf Spot of Cucurbits - *Pseudomonas Bacteria***

Angular leaf spot may be transmitted via seed. Lesions on leaves and fruit of pumpkin and squash are similar in appearance to those of bacterial leaf and fruit spot.

**Crop rotation** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Rotate to noncucurbit crops at least 2 years. Rotate between crop families to reduce pest and disease inoculum buildup and weeds favored by the management of certain crops.

**Variety selection** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Some cucumber varieties may have host resistance. Select crop varieties for competitiveness, disease resistance, and regional adaptability.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Copper applications in the transplant greenhouse or in the very early season are effective against angular leaf spot. Applying copper tank-mixed with mancozeb products (e.g., Dithane®, Manzate®, Penncozeb®) is more effective than copper alone. REI: see label.

### ***Anthracnose of Cucurbits - *Colletotrichum* Fungus***

Race 1 of the fungal pathogen that causes anthracnose affects mainly cucumber — many watermelon varieties are resistant to Race 1. Race 2 affects mainly watermelon. Lesions of this disease may be observed from transplant stage through harvest on leaves, stems, and fruit.

*Winter/Off-season:* Rotate crops at least 3 years and practice fall tillage. Rotation with non-cucurbit crops will decrease the threat of anthracnose in future years. May be seedborne.

*Greenhouse:* Scout for disease. Apply fungicide labeled for greenhouse if disease threatens.

*Planting:* Inspect seedlings. Avoid planting diseased seedlings.

*Vine Touch:* Apply contact or systemic fungicides at 7-14 day intervals or according to MELCAST — see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST*, available from the Purdue Extension Education Store, [www.edustore.purdue.edu](http://www.edustore.purdue.edu).

*Harvest:* Inspect fruit. Avoid saving seed.

**Crop rotation** *Cantaloupe/Muskmelon, Cucumber, Watermelon* Use a crop rotation of 2-3 years of non-cucurbit crops. Rotate between crop families to reduce pest and disease inoculum buildup and weeds favored by the management of certain crops.

**Aprovia Top® (difenoconazole, benzovindiflupyr (solatenol))** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.5-13.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Cabrio EG® (pyraclostrobin)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 12-16 oz. per acre. See warnings under *Alternaria leaf blight*. REI: 12-hour.

### **chlorothalonil formulations (chlorothalonil)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* See label. Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. REI: 12-hour. PHI: 0-day.

### **Inspire Super® (difenoconazole, cyprodinil)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

### **Luna Sensation (fluopyram, trifloxystrobin)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* 7.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

### **mancozeb formulations (mancozeb)**

*Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Dithane®, Manzate®, Penncozeb®, and Roper® are labeled for use at various rates. REI: 24-hour. PHI: 5-day PHI.

### **mancozeb formulations (mancozeb)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* See label. Dithane®, Manzate®, and Penncozeb® are available for use at various rates. REI: 24-hour. PHI: 5-day.

**Merivon® (fluxapyroxad, pyraclostrobin)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 5.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

### **Orondis Opti Premix® (oxathiapiprolin, chlorothalonil)**

*Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.75-2.5 pts. per acre. See label. REI: 12-hour. PHI: 0-day.

**Pristine 38WG (boscalid, pyraclostrobin)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 18.5 oz. per acre. REI: 12-hour. PHI: 0-day.

### **Quadris 2.08SC® (azoxystrobin)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* 11-15.4 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

### **Quadris Opti® (azoxystrobin, chlorothalonil)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* 3.2 pts. per acre. REI: 12-hour. PHI: 1-day PHI.

### **Quadris Top® (azoxystrobin, difenoconazole)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* 12-14 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

### **Tanos® (famoxadone, cymoxanil)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* 8 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

### **Topsin 4.5FL® (thiophanate-methyl)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* 10 fl. oz. per acre. REI: see label. PHI: 1-day.

**Topsin M WSB® (thiophanate-methyl) Cantaloupe/ Muskmelon, Cucumber, Watermelon** 0.5 lb. per acre. REI: see label. PHI: 1-day.

### **Bacterial Fruit Blotch of Cucurbits - Acidovorax Bacteria**

**Actigard® (acibenzolar-s-methyl) Cantaloupe/ Muskmelon, Cucumber, Pumpkin, Squash, Watermelon** 0.5-1 oz. per acre. Apply with two of the fixed copper product applications described for bacterial fruit blotch. REI: 12-hour. PHI: 0-day.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon** See label. Several fixed copper products are labeled at various rates. Apply fixed copper 2 weeks prior to the opening of the first female bloom, at first female bloom, and 2 weeks after the first female bloom. Later in the season, fixed copper products may be applied to help reduce disease spread. No more than 6 applications per season. REI: see label. PHI: See label.

### **Bacterial Wilt of Cucurbits - *Erwinia* Bacteria**

This disease affects pumpkins and squash only when striped and spotted beetles feed on the plants before the 5 true leaf stage. Disease control depends on control of striped and spotted cucumber beetles. Regularly scout fields for beetles.

**Winter/Off-season:** The disease is unaffected by crop rotation.

**Planting:** Apply systemic insecticides such as Admire® or Platinum® (see Insect Control section) at transplant. Apply contact insecticides after systemic insecticides lose effectiveness (2-3 weeks). Apply foliar insecticides only when beetles are present. When large numbers are present, treatments may be required twice weekly. Scout fields regularly for cucumber beetles.

**Insecticides** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash* Apply systemic insecticides such as Admire® or Platinum® (see Insect Control section) at transplant. Apply contact insecticides after systemic insecticides lose effectiveness (2-3 weeks). Apply foliar insecticides only when cucumber beetles are present. When large numbers are present, treatments may be required twice weekly. Scout fields regularly for cucumber beetles.

### **Crown and Root Rot of Multiple Crops -**

#### ***Phytophthora* Oomycete**

*Phytophthora* is often associated with heavy rains and fields with poor drainage. Raised beds may help lessen

disease severity. The first symptoms are usually observed in low areas. No resistant varieties are available.

**Winter/Off-season:** Use crop rotations of 4 years or more that do not include solanaceous crops. Avoid fields with a history of a disease.

**Planting:** Direct-seeded crops benefit from fungicide-treated seed (see discussion of fungicide seed treatment under Damping-off). Treat seed with Apron XL LS® to help prevent *Phytophthora* infection for 5 weeks from time of seeding. Ponds with run-off water from infested soil may be contaminated with *Phytophthora*. Use crop rotations of at least three years with non-cucurbits and non-solanaceous crops and effective weed management (nightshade and velvet leaf are hosts of this pathogen).

**Vine Touch:** Apply contact or systemic fungicides at first sign of the disease. Systemic fungicides are available.

**Harvest:** Identify fruit problems. Sanitation is very important to prevent the spread of the disease.

**Crop rotation** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Use crop rotations that avoid eggplant, pepper, snap beans and cucurbit crops for at least 4 years. Rotate between crop families to reduce pest and disease inoculum buildup and weeds favored by the management of certain crops.

**Apron XL® (mefenoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Seed treatment. Only for direct-seeded plants. REI: 48-hour.

**Elumin® (ethaboxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 8 fl. oz. per acre. Tank-mixing this product with a contact fungicide such as chlorothalonil or mancozeb will help reduce resistance concerns. See label for drip irrigation instructions. REI: 12-hour. PHI: 2-day.

**Forum 4.18SC® (dimethomorph)** *Cantaloupe/ Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Gavel 75DF® (zoxamide, mancozeb)** *Cantaloupe/ Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.5-2.0 lbs. per acre. REI: 48-hour. PHI: 5-day.

**Orondis Gold® (oxathiapiprolin, mefenoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 4.8-9.6 fl. oz. per acre. Soil application. See label for details. REI: 4-hour. PHI: 0-day.

**Orondis Ultra Premix® (oxathiapiprolin, mandipropamid)** *Cantaloupe/Muskmelon,*

*Cucumber, Pumpkin, Squash, Watermelon* 5.5-8.0 fl. oz. per acre. See label for details. REI: 4-hour. PHI: 0-day.

**phosphite and phosphorous acid formulations (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Several phosphite or phosphorus acid products (Agri-Fos®, Phostrol®, Prophyt®, Rampart®) are labeled at various rates. Label includes different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until Phytophthora blight is observed. REI: see label.

**Presidio® (fluopicolide)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 4 fl. oz. per acre. REI: 12-hour. PHI: 2-day.

**Ranman 400SC® (cyazofamid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.75 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Revus® (mandipropamid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 8 fl. oz. per acre. Suppression only. REI: 4-hour. PHI: 0-day.

**Tanos® (famoxadone, cymoxanil)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 8-10 oz. per acre. Suppression only. REI: 12-hour. PHI: 3-day.

**Zampro® (ametoctradin, dimethomorph)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 14 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

### **Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens**

Practice good greenhouse sanitation. The best way to prevent damping-off of seedlings in the greenhouse is to keep the greenhouse area clean. See section on Transplant Production, page 23.

Plant in warm field soils. The fungi responsible for damping-off in field soils cause more loss when the seedling is slow to emerge.

Using treated seed may help reduce the severity of damping-off if used with the cultural methods discussed above. Seed treated with contact fungicides with the active ingredients thiram or captan may help reduce the decay of the seed prior to emergence. Systemic products are designed to move into the seedling and help manage

damping-off in the first two to three weeks. Examples of systemic products include Apron XL®, Dynasty®, and Maxim 4FS®. Seed that is treated with all three of these systemic products is available with the trade name Farmore 300®. Vegetable seed that is usually transplanted (such as muskmelon and watermelon) are less likely to benefit from fungicide seed treatments than crops that are direct seeded (such as pumpkin).

**Apron XL® (mefenoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* See label. Seed treatment will help prevent damping-off caused by Phytophthora and Pythium. REI: 48-hour. PHI: See label.

**Dynasty® (azoxystrobin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* See label. Seed treatment will help prevent damping-off caused by Rhizoctonia spp. REI: 4-hour. PHI: See label.

**Maxim 4FS® (fludioxonil)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* See label. See treatment will help prevent damping-off caused by Rhizoctonia spp. REI: 12-hour. PHI: See label.

**Previcur Flex® (propamocarb)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* See label. See label for greenhouse uses and details about managing damping-off caused by Pythium species. REI: 12-hour. PHI: See label.

**Ridomil Gold SL® (mefenoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1-2 pts. per acre. For use on damping-off caused by Pythium species. REI: 48-hour. PHI: See label.

### **Downy Mildew of Cucurbits -**

#### ***Pseudoperonospora Oomycete***

The fungus-like organism that causes downy mildew, *Pseudoperonospora cubensis*, does not survive Midwest winters because it requires green, living plant tissues. That means the fungus-like organism only overwinters in south Florida or in greenhouses in northern U.S and Canada. The wind carries downy mildew spores to new, living hosts, but, depending on conditions, it can be quite late in the growing season before the spores reach the Midwest. Downy mildew of cucurbits may occur as early as mid-July or may not show up in at all in a particular growing season. Since pumpkins are grown until relatively late in the growing season, this crop is often affected more than other cucurbits.

Strains of the downy mildew pathogen are known to exist that are resistant to some fungicides. Strobilurin fungicides (such as Cabrio®, Flint®, Merivon®, Pristine®, Quadris®, Reason®, Satori®) and fungicides with the

active ingredient mefenoxam (such as Ridomil®) are particularly prone to resistance. In addition, Revus® and Previcur Flex® have occasionally been ineffective for management of downy mildew. See Selected Information About Recommended Fungicides (page 79) for more information.

**Catamaran® (potassium phosphite, chlorothalonil)**

*Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6 pts. per acre. REI: 12-hour. PHI: 1-day.

**chlorothalonil formulations (chlorothalonil)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* See label. Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. REI: 12-hour. PHI: 0-day.

**Elumin® (ethaboxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 8 fl. oz. per acre. Tank-mixing this product with a contact fungicide such as chlorothalonil or mancozeb will help reduce resistance concerns. REI: 12-hour. PHI: 2-day PHI.

**Forum 4.18SC® (dimethomorph)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6 fl. oz. per acre. REI: 12-hour. PHI: 0-day PHI.

**Gavel 75DF® (zoxamide, mancozeb)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.5-2.0 lbs. per acre. REI: 48-hour. PHI: 5-day PHI.

**mancozeb formulations (mancozeb)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Dithane®, Manzate®, Penncozeb®, and Roper® are labeled for use at various rates. REI: 24-hour. PHI: 5-day PHI.

**Omega 500F® (fluazinam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 0.75-1.5 pts. per acre. REI: see label. PHI: 30-day PHI.

**Orondis Opti Premix® (oxathiapiprolin, chlorothalonil)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.75-2.5 pts. per acre. See label. REI: 12-hour. PHI: 0-day.

**Orondis Ultra Premix® (oxathiapiprolin, mandipropamid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* See label. May be available as a co-pack. Apply according to rates on each container. REI: 4-hour. PHI: 0-day PHI.

**phosphite and phosphorous acid formulations (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and**

**ammonium phosphites, fosetyl-aluminum)**

*Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Various. Several phosphite or phosphorus acid products are labeled at various rates such as (AgriFos®, Phostrol®, Prophyte®, Rampart®). Label includes several different crops, PHIs, resistance instructions, and other important information. Some manufacturers recommend tank-mixing. These products may be used in a preventative program until downy mildew is observed. REI: see label. PHI: 0-day PHI.

**Presidio® (fluopicolide)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 4 fl. oz. per acre. REI: 12-hour. PHI: 2-day.

**Ranman 400SC® (cyazofamid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.1-2.75 fl. oz. per acre. REI: 12-hour. PHI: 0-day PHI.

**Revus® (mandipropamid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 8.0 fl. oz. per acre. REI: 4-hour. PHI: 0-day PHI.

**Tanos® (famoxadone, cymoxanil)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 8.0 oz. per acre. REI: 12-hour. PHI: 3-day PHI.

**Fruit Rot of Cucurbits - Fusarium Fungus**

No resistant varieties are available. Fruit with Fusarium fruit rot are often observed from fields where other disease or cultural problems are present.

**Winter/Off-season:** Rotate with noncucurbit crops at least 4 years. Avoid fields with a history of disease. May be seedborne.

**Planting:** Manage foliar diseases for better fruit health. Avoid other fruit diseases, such as bacterial fruit spot or Phytophthora blight.

**Harvest:** Identify fruit problems.

**Crop rotation** *Cantaloupe/Muskmelon, Pumpkin*

Rotate between crop families to reduce pest and disease inoculum buildup and weeds favored by the management of certain crops.

**Fusarium Wilt of Vine Crops - Fusarium Fungus**

Plant watermelon cultivars with partial resistance. See table on page in this section. Rotate with noncucurbit crops to decrease incidence of wilt.

**Crop rotation** *Watermelon* Rotate with noncucurbit crops to decrease disease severity. Rotate between crop families to reduce pest and disease inoculum buildup and weeds favored by the management of certain crops.

**Variety selection** *Cantaloupe/Muskmelon* Plant resistant cantaloupe cultivars. Several cultivars have good resistance to strains of Fusarium. Select crop varieties for competitiveness, disease resistance, and regional adaptability.

**Variety selection** *Watermelon* Plant watermelon varieties with partial resistance. Select crop varieties for competitiveness, disease resistance, and regional adaptability.

**Proline 480SC (prothioconazole)** *Watermelon* 5.7 fl. oz. per acre. May be applied by ground or chemigation application equipment. Do not use in water used for hand transplanting REI: 12-hour. PHI: 7-day.

### **Gummy Stem Blight/Black Rot of Cucurbits - *Didymella* Fungus**

Gummy stem blight may occur on cucurbits from transplant through harvest. The leaves and stems may be affected. Occasionally, fruit are affected, which is known as black rot. The black rot phase of the disease is more common in pumpkins than the gummy stem blight phase.

Strains of the gummy stem blight fungus are known to exist in the Midwest that are resistant to some fungicides. Strobilurin fungicides in Group 11 (such as Cabrio®, Flint®, Merivon®, Pristine®, Quadris®, Satori®) and fungicides with the active ingredient boscalid Group 7 (such as Fontelis® and Pristine®) are particularly susceptible to resistance: for this reason, these products are not listed here. See Selected Information About Recommended Fungicides, page 79. Tank-mix these products with products that have a different mode of action in situations where resistance may be a factor.

**Winter/Off-season:** Rotate crops at least 3 years and practice fall tillage. May be seedborne.

**Greenhouse:** Scout for disease. Apply fungicide labeled for greenhouse if necessary.

**Planting:** Avoid planting diseased seedlings in the field.

**Vine Touch:** Apply contact or systemic fungicides at 7-14 day intervals or according to MELCAST — see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST*, available from the Purdue Extension Education Store, [www.edustore.purdue.edu](http://www.edustore.purdue.edu).

**Harvest:** Identify fruit problems.

**Crop rotation** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Rotate to noncucurbit crops for at least 3 years. Rotate between crop families to reduce pest and disease inoculum buildup and weeds favored by the management of certain crops.

### **chlorothalonil formulations (chlorothalonil)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* See label. Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. REI: 12-hour. PHI: 0-day.

### **Inspire Super® (difenoconazole, cyprodinil)**

*Cantaloupe/Muskmelon, Cucumber, Watermelon* 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

### **Luna Experience® (fluopyram, tebuconazole)**

*Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10-17 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

### **mancozeb formulations (mancozeb)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon*

Dithane®, Manzate®, Penncozeb®, and Roper® are labeled for use at various rates. REI: 24-hour. PHI: 5-day PHI.

### **Merivon® (fluxapyroxad, pyraclostrobin)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 5.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

### **Miravis Prime® (pydiflumetofen, fludioxonil)**

*Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 9.2-11.4 fl. oz. per acre. An adjuvant may be added at recommended rates. REI: 12-hour. PHI: 1-day.

### **Orondis Opti Premix® (oxathiapiprolin, chlorothalonil)**

*Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.75-2.5 pts. per acre. See label. REI: 12-hour. PHI: 0-day.

### **Switch 62.5WG® (cyprodinil, fludioxonil)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 11-14 oz. per acre. REI: 12-hour. PHI: 1-day.

### **tebuconazole formulations (tebuconazole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 8 fl. oz. per acre. REI: see label. PHI: 7-day.

### **Leaf Blight of Cucurbits - *Alternaria* Fungus**

*Alternaria* leaf blight (ALB) primarily affects cantaloupe. ALB symptoms may occur on leaves from May through harvest.

**Winter/Off-season:** Rotate crops at least 2 years and practice fall tillage.

**Vine Touch:** Apply contact or systemic fungicides at 7-14 day intervals or according to MELCAST — see Purdue Extension publication BP-67-W, *Foliar Disease Fungicide Control Using MELCAST*, available from the Purdue Extension Education Store, [www.edustore.purdue.edu](http://www.edustore.purdue.edu).

**Harvest:** Fungicide applications are unnecessary within 2-3 weeks of final harvest.

**Crop rotation** *Cantaloupe/Muskmelon* Use a crop rotation of noncucurbit crops for 2-3 years. Rotate between crop families to reduce pest and disease inoculum buildup and weeds favored by the management of certain crops.

**Aprovia Top® (difenoconazole, benzovindiflupyr (solanenol))** *Cantaloupe/Muskmelon* 10.5-13.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Cabrio EG® (pyraclostrobin)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 12-16 oz. per acre. See warnings under Alternaria leaf blight. REI: 12-hour.

**chlorothalonil formulations (chlorothalonil)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* See label. Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. REI: 12-hour. PHI: 0-day.

**Fontelis® (pentiopyrad)** *Cantaloupe/Muskmelon* 12-16 fl. oz. per acre. See label for greenhouse uses. REI: 12-hour. PHI: 1-day.

**Gavel 75DF® (zoxamide, mancozeb)** *Cantaloupe/Muskmelon* 1.5-2 lbs. per acre. REI: 48-hour. PHI: 5-day.

**Inspire Super® (difenoconazole, cyprodinil)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Luna Experience® (fluopyram, tebuconazole)** *Cantaloupe/Muskmelon* 6-17 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** *Cantaloupe/Muskmelon* 7.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**mancozeb formulations (mancozeb)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Dithane®, Manzate®, Penncozeb®, and Roper® are labeled for use at various rates. REI: 24-hour. PHI: 5-day PHI.

**Merivon® (fluxapyroxad, pyraclostrobin)** *Cantaloupe/Muskmelon* 4-5.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Miravis Prime® (pydiflumetofen, fludioxonil)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 9.2-11.4 fl. oz. per acre. An adjuvant may be added at recommended rates. REI: 12-hour. PHI: 1-day.

*OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.*

**Orondis Opti Premix® (oxathiapiprolin, chlorothalonil)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.75-2.5 pts. per acre. See label. REI: 12-hour. PHI: 0-day.

**Pristine 38WG® (boscalid, pyraclostrobin)** *Cantaloupe/Muskmelon* 12.5-18.5 oz. per acre. REI: 12-hour. PHI: 0-day.

**Quadris 2.08SC® (azoxystrobin)** *Cantaloupe/Muskmelon* 11-15.5 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

**Quadris Opti® (azoxystrobin, chlorothalonil)** *Cantaloupe/Muskmelon* 3.2 pts. per acre. REI: 12-hour. PHI: 1-day.

**Quadris Top® (azoxystrobin, difenoconazole)** *Cantaloupe/Muskmelon* 12-14 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

**Satori® (azoxystrobin)** *Cantaloupe/Muskmelon* 11-15.5 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

**Switch 62.5WG® (cyprodinil, fludioxonil)** *Cantaloupe/Muskmelon* 11-14 oz. per acre. REI: 12-hour. PHI: 1-day.

**Tanos® (famoxadone, cymoxanil)** *Cantaloupe/Muskmelon* 8 oz. per acre. REI: 12-hour. PHI: 3-day.

### **Leaf Blight of Cucurbits - *Plectosporium* Fungus**

*Plectosporium* blight primarily affects pumpkin. Leaves, stems, and occasionally fruit can be affected.

**Winter/Off-season:** Rotate cucurbit crops 3-4 years and practice fall tillage. Choose fields with well-drained soil.

**Vine Touch:** Start applying contact/systemic fungicide applications and continue at 7-14 day intervals.

**Harvest:** Identify fruit problems.

**Crop rotation** *Pumpkin, Squash* Crop rotations of 3-4 years in a noncucurbit crops should help to lessen disease severity. Rotate between crop families to reduce pest and disease inoculum buildup and weeds favored by the management of certain crops.

**Cabrio EG® (pyraclostrobin)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 12-16 oz. per acre. See warnings under Alternaria leaf blight. REI: 12-hour.

**Flint® (trifloxystrobin)** *Pumpkin, Squash* 1.5-2.0 oz. per acre. REI: 12-hour. PHI: 0-day.

**Inspire Super® (difenoconazole, cyprodinil)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**mancozeb formulations (mancozeb)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Dithane®, Manzate®, Penncozeb®, and

Roper® are labeled for use at various rates. REI: 24-hour. PHI: 5-day PHI.

**Merivon® (fluxapyroxad, pyraclostrobin)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 5.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Quadris 2.08SC® (azoxystrobin)** *Pumpkin, Squash* 11-15.4 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

### **Leaf Spot and Fruit Spot of Cucurbits - *Xanthomonas* Bacteria**

Bacterial leaf and fruit spot occurs primarily on pumpkin and winter squash. Symptoms on leaves may occur from the 4-leaf stage through the remainder of the season.

Fruits can be infected from time of set until harvest. Only fruit symptoms are of economic importance. Bacterial leaf and fruit spot lesions may be colonized by other organisms (such as *Fusarium* and soft-rot bacteria), which results in fruit rot.

The bacterial leaf and fruit spot pathogen can survive on infected leaf and fruit residues for more than 24 months. Also, the pathogen can be transmitted in and on seed for longer than 20 months. Leaf symptoms of this disease may be similar to angular leaf spot caused by *Pseudomonas* bacterium. The only known hosts of the leaf spot pathogen (*Xanthomonas*) are plants in the cucurbitaceae family.

**Winter/Off-season:** Rotate crops at least 3 years with noncucurbit crops, and practice fall tillage. Bacteria in and on the seeds can be eradicated by hot-water at 55 C for 15 min.

**Planting:** Treat with fixed copper compounds mixed with mancozeb products if symptoms are present.

**Vine Touch:** Apply fixed copper mixed with mancozeb when fruit is softball-sized. Continue applications until fruit set is complete. **Harvest:** Do not save seed from affected fields. Identify fruit problems.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Pumpkin, Squash* Copper applications at 7-day intervals beginning when fruit are 4-5 inches in diameter. Applying copper tank-mixed with mancozeb products (e.g., Dithane®, Manzate®, Penncozeb®) is more effective than copper alone. REI: see label.

### **Powdery Mildew of Cucurbits - *Podosphaera* Fungus**

Powdery mildew is primarily a disease of cantaloupe, pumpkin, and squash. This disease does not require leaf wetness for disease initiation or spread.

Some pumpkin varieties have partial resistance to powdery mildew. Fungicide resistance has been detected in the Midwest. Fungicides in Groups 1 and 11 may not be effective. Fungicides that are affected include Cabrio®, Flint®, Quadris®, Satori®, Sovran®, and Topsin®. Alternate fungicides between MOA groups. See Selected Information About Recommended Fungicides (page 79).

**Winter/Off-season:** Crop rotation and fall tillage are moderately important. Resistant or partially resistant pumpkin cultivars are available.

**Vine Touch:** Begin systemic fungicide applications at "bush" stage of pumpkin growth. Protect pumpkin vines until approximately 21 days from last harvest.

**Variety selection** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Some varieties of cantaloupe, cucumber and pumpkin have partial resistance. Select crop varieties for competitiveness, disease resistance, and regional adaptability.

**Aprovia Top® (difenoconazole, benzovindiflupyr (soltanol))** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.5-13.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Fontelis® (penthiopyrad)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 12-16 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

**Inspire Super® (difenoconazole, cyprodinil)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Luna Experience® (fluopyram, tebuconazole)** *Cantaloupe/Muskmelon* 6-17 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 4-7.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Merivon® (fluxapyroxad, pyraclostrobin)** *Cantaloupe/Muskmelon* 4-5.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Microthiol Disperss® (sulfur)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5-10 lbs. per acre. REI: 24-hour. PHI: 0-day. OMRI-listed.

**Miravis Prime® (pydiflumetofen, fludioxonil)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 9.2-11.4 fl. oz. per acre. An adjuvant may be added at recommended rates. REI: 12-hour. PHI: 1-day.

**Procure 480SC® (triflumizole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 4-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

## Product/Disease Ratings for All Cucurbits<sup>1</sup>

Product (REI/PHI) <sup>2</sup>	Common name MOA or FRAC code: fungicides with a number as the MOA code should be tank-mixed or alternated with a different MOA code according to the label.	Alternaria leaf blight	Anthracnose	Bacterial leaf & fruit blotch	Bacterial leaf and fruit spot	Downy mildew	Gummy stem blight/black rot	Plectosporium blight	Phytophthora blight	Powdery mildew	Scab	Comments
Actigard® (12/0)	acibenzolar-S-methyl (P01)			F	P	P				P	P	Use with copper applications for bacterial fruit blotch (see page 123).
Agri-Fos®, Phostrol®, Prophyt®, Rampart® (4/0)	acid/phosphite (33)					F	F		F			Use early and in tank mixes.
Aprovio Top (12/0)	difenconazole (3), benzovindiflupyr (7)	ID	F			F	ID		G	ID		
Bravo®, Echo®, Equus®, Initiate® (12/0)	chlorothalonil (M)	G	G		F	G	G	P	F	G		
Cabrio® (12/0)	pyraclostrobin (11)	G	G		P	P	G		P			There may be resistance issues with downy mildew and gummy stem blight.
copper (active ingredient) (24/0)	copper (M)	P	P	F	F	P	P					
Dithane®, Manzate®, Penncozeb® (24/5)	mancozeb (M) phosphorus	G	G		F	G	G			G		
Elumin® (12/2)	ethaboxam (22)					G			G			Do not alternate with Gavel® or Zing!. See tank-mix recommendation on page 123.
Flint® (12/0)	trifloxystrobin (11)				P		F		P			There may be resistance issues with powdery mildew.
Fontelis® (12/1)	penthiopyrad (7)	G				P			F			There may be resistance issues with gummy stem blight.
Forum 4.18SC® (12/0)	dimethomorph (40)				G			F				Do not alternate with Revus®. Use early and in tank mixes.
Gavel® (48/5)	mancozeb (M), zoxamide (22)	G			G			F				
Inspire Super® (12/7)	difenoconazole (3), cyprodinil (9)	G	G			G	G		G			
Luna Experience® (12/7)	fluopyram (7), tebuconazole (3)	G	F			G			G			
Luna Sensation® (12/0)	trifloxystrobin (11), fluopyram (7)	G	G			F			F			
Miravis Prime (12/7)	pydiflumetofen (7), fludioxonil (12)	ID				G			ID			F
Merivon® (12/0)	fluxapyroxad (7), pyraclostrobin (11)	G	G		P	P			F			
Monsoon®, Onset®, Toledo®, Vibe® (12/7)	tebuconazole (3)					G			F			
Orondis Opti® (4/0)	oxathiapiprolin (U15), chlorothalonil (M)				G			G				
Orondis Ridomil Gold SL® (48/5)	oxathiapiprolin (U15), mefenoxam (4)							G				Soil-applied product.
Orondis Ultra® (4/0)	oxathiapiprolin (U15), mandipropamid (40)				G			G				
Presidio 4SC® (12/2)	fluopicolide (43)				G			G				Primary use will be for Phytophthora blight in rotation with Revus®.
Previcur Flex® (12/2)	propamocarb (28)				P							Has greenhouse label for damping-off
Pristine® (12/0)	boscalid (7), pyraclostrobin (11)	G	G		P	P			P			There may be resistance issues with downy mildew and gummy stem blight.
Procure® (12/0)	triflumizole (3)								G			
Quadris®, Satori® (4/1)	azoxystrobin (11)	G	G		P	P	G		P			There may be resistance issues with downy mildew and gummy stem blight.
Quadris Opti® (12/1)	azoxystrobin (11), chlorothalonil (M)	G	G		P	P			F			
Quadris Top® (12/1)	azoxystrobin (11), difenconazole (3)	G	G			G			P			
Quintec® (12/3)	quinoxyfen (13)								G			Contact fungicide with single mode of action
Rally® (24/0)	mycolobutanil (3)								G			
Ranman® (12/0)	cyazofamid (21)				G			G				
Revus® (4/0)	mandipropamid (40)					P			G			Primary use will be for Phytophthora blight in rotation with Presidio®.
Switch 62.5WB® (12/1)	cyprodinil (9), fludioxonil (12)	G				G			F			
Tanos® (12/3)	cymoxanil (27), famoxadone (11)	G	G	S	F			S				
Topsin M® (12/0)	thiophanate-methyl (1)	G			F			P				
Torino® (4/0)	cylflufenamid (U6)								F			
Velum Prime (12/0)	Fluopyram (7)								ID			Also labeled for root-knot nematode.
Vivando® (12/0)	metrafenone (U8)								G			
Zampro® (12/0)	ametoctradin (45), dimethomorph (40)					G			G			See label for directions for at planting drench.
Zing® (12/0)	zoxamide (22), chlorothalonil (M)	G	G		G							

<sup>1</sup>Fungicide rating code: G=good. F=fair. P=poor. S=suppression only. ID=labeled, but insufficient data to allow rating. Based on research and experience of the authors.<sup>2</sup>REI (re-entry interval) in hours: do not enter or allow workers to enter areas treated during the REI period. PHI (pre-harvest interval) in days: the minimum time that must pass between the last pesticide application and crop harvest.

**Quintec® (quinoxyfen)** *Cantaloupe/Muskmelon, Pumpkin, Squash, Watermelon* 4-6 fl. oz. per acre. May cause leaf yellowing. Product is a contact fungicide. Labeled for winter squash—not summer squash. REI: 12-hour. PHI: 3-day.

**Rally 40WSP® (myclobutanil)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.5-5.0 oz. per acre. REI: 24-hour. PHI: 0-day.

**tebuconazole formulations (tebuconazole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 4-6 fl. oz. per acre. Trade names of labeled products include Monsoon®, Onset®, and Toledo®. REI: see label. PHI: 7-day.

**Torino® (cyflufenamid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 3.4 oz. per acre. REI: 4-hour. PHI: 0-day.

**Velum Prime® (fluopyram)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.5-6.84 fl. oz. per acre. May cause a mild yellowing of leaf margins. May be applied through drip. REI: 12-hour. PHI: 0-day.

**Vivando® (metrafenone)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 15.4 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

### **Root-Knot Nematode**

*Winter/off-season:* Root-knot nematodes have a host range of more than 2,000 plants, so crop rotation is often ineffective unless a grain crop is used. Certain cover crops may lessen symptom severity.

*Planting:* Vydate® at planting may manage moderate nematode populations. Fumigants may be used for higher nematode populations.

*Harvest:* Examine stunted and wilting plants for the presence of root-knot nematodes.

**InLine® (1,3-dichloropropene)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* See label. REI: See label. PHI: See label. RUP.

**Nimitz® (fluensulfone)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 3.5-7 pts. per acre. Do not use on direct-seeded plants. May be broadcast, banded, or drip-applied. 7-day plant back interval. REI: see label. PHI: See label.

**Telone C-17® (1,3-dichloropropene, chloropicrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* See label. REI: see label. PHI: See label. RUP.

**Telone C-35® (1,3-dichloropropene, chloropicrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin,*

*Squash, Watermelon* See label. REI: see label. PHI: See label. RUP.

**Telone II® (1,3-dichloropropene)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* See label. REI: see label. PHI: See label. RUP.

**Vapam HL® (metam sodium)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* See label. REI: see label. PHI: See label. RUP.

**Velum Prime® (fluopyram)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.5-6.84 fl. oz. per acre. May cause a mild yellowing of leaf margins. May be applied through drip. REI: 12-hour. PHI: 0-day.

**Vydate L® (oxamyl)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* See label. Use in 20 gals. of water per acre broadcast. Incorporate 2-4 inches. REI: 48-hour. PHI: 1-day. RUP.

### **Scab of Cucurbits - Cladosporium Fungus**

Scab lesions may be observed on the fruit of most cucurbit crops. Fungicides used for gummy stem blight control may help. Fungicides may be ineffective when temperatures of less than 57°F persist for longer than 9 hours.

*Winter/Off-season:* Rotate crops 3-4 years and practice fall tillage. Use disease-free seed.

*Planting:* Fungicides may help to reduce the severity of scab if applied before fruit development.

*Harvest:* Inspect fruit for symptoms of scab.

**Crop rotation** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Use a crop rotation that avoids cucurbits for 2-3 years. Rotate between crop families to reduce pest and disease inoculum buildup and weeds favored by the management of certain crops.

**Variety selection** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Use cucumber varieties with host resistance to scab. Select crop varieties for competitiveness, disease resistance, and regional adaptability.

### **Viruses of Multiple Crops - Multiple Pathogens**

Aphids transmit virus diseases, including cucumber mosaic virus, papaya ring spot virus, watermelon mosaic virus, and zucchini yellow mosaic virus. Since these diseases usually appear later in the season, they most often affect pumpkin and squash. All varieties are susceptible to these viruses.

It may help to kill perennial weeds (virus source plants) within 150 feet of planting. Controlling aphids (virus carriers) by insecticides can reduce secondary spread

of viruses but does not reduce initial infection and rarely results in any decrease in the incidence of virus symptomatic fruit. Early planting and development of pumpkins and squash fruit before virus diseases become prevalent may reduce symptoms on fruit.

**Planting:** Earlier planted or earlier maturing pumpkin cultivars will help to avoid severe disease problems.

**Vine Touch:** Control weeds in and around production area.

**Variety selection** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Varieties with host resistance include cucumbers (cucumber mosaic virus) and squash (watermelon mosaic virus; zucchini yellow mosaic virus; cucumber mosaic virus; papaya ringspot virus). Select crop varieties for competitiveness, disease resistance, and regional adaptability.

### Common Cucurbit Viruses and Transmission Sources

Virus	Host Range	Transmission Source
Cucumber Mosaic Virus	wide	aphids <sup>1</sup>
Papaya Ring Spot Virus	Cucurbitaceae	aphids <sup>1</sup>
Squash Mosaic Virus	Cucurbitaceae, Chenopodiaceae	seeds, cucumber beetles
Watermelon Mosaic Virus	Cucurbitaceae, weeds	aphids <sup>1</sup>
Zucchini Yellow Mosaic Virus	Cucurbitaceae	aphids <sup>1</sup>

<sup>1</sup>Aphidborne viruses are non-persistent, thus aphids can begin transmitting the virus after seconds of feeding, and may transmit the virus for only a few hours.

## Weed Control

Weed control methods in cucurbits vary by production system. The challenges for those who rely on herbicides include the chance of injuring crops under adverse weather, the relatively short residual of preemergence herbicides, and the lack of a broad-spectrum postemergence broadleaf herbicide that can be applied over the top of the crop.

For cucurbits that are no-till direct-seeded into a killed crop (such as pumpkins after soybeans, rye cover crop, or wheat) growers often use a burndown herbicide with a preemergence herbicide. If residue and cucurbit vines are not sufficient to suppress later-emerging weeds, growers may use postemergence herbicides, or shielded applications of nonselective herbicides.

For cucurbits direct-seeded into tilled soil, growers often combine one or more preemergence herbicides

at planting with one or more cultivations. Sometimes, growers also apply a preemergence herbicide at the last cultivation to improve control of late-emerging weeds. If needed, growers may use postemergence herbicides or shielded applications of nonselective herbicides.

When cucurbits are transplanted into plastic mulch, some growers apply a preemergence herbicide under the mulch as well as between the rows. Other growers only apply between the rows. Growers may also use one or more cultivations, and if needed, postemergence herbicides or a shielded application of a nonselective herbicide.

In organic production, organic mulches, plastic mulch, cultivation, and hand-weeding are common. Planting on the square will allow cultivation in two directions.

Weed pressure may be substantially reduced when growers prepare seedbeds several weeks in advance of planting and kill the first one or two flushes of weeds before planting without stirring up new weed seeds. Cucurbits lend themselves to this stale seedbed practice because they are often planted after common weeds have emerged in tilled soil.

The more quickly cucurbit vines cover the soil surface, the better they will suppress late-emerging weeds. Closer row spacing promotes rapid vine cover, and growers can increase in-row spacing to maintain a constant plant population. Uniform plant spacing in the row will also promote uniform vine cover. Seeding equipment that allows large gaps in direct-seeded crops usually leads to weed patches where the crop population is lower.

## Recommended Controls

### Burndown or Directed/Shielded Application

#### Broadleaf and Grass Weeds

glyphosate formulations (glyphosate) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal) at 0.66-3.3 qts. per acre. Broadcast 3 days before transplanting or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. Remove herbicide residue from plastic mulch prior to transplanting. REI: 4-hour. PHI: 14-day.

paraquat formulations (paraquat) *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2-4 pts. per acre of 2 lb. per gal.

formulations or 1.3-2.7 pt. per acre of 3 lb. per gal. formulations. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS (0.25% v/v) per 25 gal. of solution and apply to emerged weeds less than 6" tall prior to transplanting or after direct-seeding but before crop emergence. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 24-hour. RUP.

### **Burndown or Directed/Shielded Application**

#### **Broadleaf Weeds**

**Aim EC® (carfentrazone)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 0.5-2 fl. oz. per acre. Apply a minimum of 1 day prior to transplanting or 7 days prior to direct-seeding or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season REI: 12-hour. PHI: 0-day.

### **Preemergence Broadleaf and Grass Weeds**

#### **Command 3ME® (clomazone) at the following rates:**

*Cantaloupe/Muskmelon, Watermelon* 0.4-0.67 pt. per acre.

*Cucumber* 0.4-1.0 pt. per acre. PHI: 45-day.

*Pumpkin, processing pumpkins only: not for jack-o-lantern pumpkin* 0.67-2.0 pt. per acre. PHI: 45-day.

*Squash* 0.67-1.33 pts. per acre for summer squash, 0.67-2.0 pts. per acre for winter squash. PHI: 45-day.

Not for jack-o-lantern pumpkins; see label for sensitive varieties. Apply prior to seeding or transplanting, or after seeding before crop emergence. Does not control pigweed and related species. Rates below 1 pt. will only suppress weeds. May cause temporary bleaching of crop leaves. REI: 12-hour.

**Curbit EC® (ethalfluralin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 3-4 pt. per acre. Use lower rates on coarse soils. *Direct-seeded:* apply to soil surface within 2 days after seeding. Do not incorporate. *Transplants:* apply as a banded spray between rows. Does not control large-seeded broadleaves. Needs 0.5 inch of water within 5 days of application to be effective. If no rain occurs, cultivate shallowly. Do not apply over or under hot caps, row covers, or plastic mulch. Do not broadcast over top

of plants. Under cool temperatures may cause crop injury or failure. REI: 24-hour.

#### **Dual Magnum® (s-metolachlor) at the following rates:**

*Note: Applicators must have 24c label, when applicable. Illinois label expires March 25, 2024. Michigan and Ohio labels expire December 31, 2021. REI: 24-hour.*

*Cantaloupe/Muskmelon, Watermelon in Illinois,*

*Indiana, Michigan, and Ohio only:* 0.67-1.27 pt. per acre. For crops on plastic mulch, apply between rows after laying mulch, but before crop emergence or transplanting. For crops on bare ground, apply before transplanting, or after seeding before crop emergence. On bare ground, the herbicide may be broadcast or applied just between rows. There is less risk of crop injury if applied between rows, and if melons are transplanted rather than seeded. Will not control emerged weeds. Do not exceed 1.27 pt. per acre or 1 application per crop per season. PHI: 60-day.

*Cucumber in Illinois, Indiana, Michigan, and Ohio only:* 0.67-1.0 pt. per acre. Apply after seeding before weeds or crop emerge, or apply broadcast after cucumbers have 1-2 true leaves. Will not control emerged weeds. Do not exceed 1 pt. per acre or 1 application per crop per season. PHI: 30-day.

*Pumpkin* 1.0-1.33 pt. per acre. Apply between rows or hills. Leave an untreated area at least 1 foot wide over the planted row, or at least 6 inches from planted seed or pumpkin leaves. *Additional application methods are permitted in Illinois, Indiana, and Michigan only:* Apply as a broadcast over top or between crop rows after seeding and before crop emergence. Will not control emerged weeds. Do not exceed 1.3 pt. per acre per crop. PHI: 30-day.

*Winter squash in Illinois, Indiana, Michigan, and Ohio only:* 1.0-1.3 pt. per acre. Apply as a broadcast over top or between crop rows after seeding and before crop emergence. Will not control emerged weeds. Do not exceed 1.3 pt. per acre per crop. PHI: 30-day.

*Summer squash in Illinois, Indiana, and Michigan only:* 0.67-1.33 pt. per acre. Apply as broadcast over the top or between crop rows after seeding and before crop emergence. If crops are grown on plastic mulch, the preemergence application should be made before laying the plastic. May also be applied as a row middle application after

the laying of the plastic mulch and after crop emergence. Will not control emerged weeds. Do not exceed 1.33 pt. per acre per crop. PHI: 30-day.

**Prowl H2O® (pendimethalin)** *Cantaloupe/Muskmelon, Watermelon* 2.1 pt. per acre. Apply to row middles only. Use a shielded sprayer with 6 inches on either side of the row middles. Apply before transplanting or before emergence of direct-seeded crop. A second application may be made before vines run. Wait at least 21 days between applications. Do not exceed 2.1 pt. per acre per application or 4.2 pt. per acre per season. REI: 24-hour. PHI: 35-day.

**Sinbar WDG® (terbacil)** *Watermelon* 2-4 oz. per acre. Apply pre-transplanting to bare ground or under plastic mulch, or to row middles. For direct-seeded crops on bare ground, apply after planting but before crop emergence. Do not allow spray to contact crop. Do not plant other crops within 2 years of application. Do not use on sand or gravel soils. Not recommended on soils with less than 1% organic matter due to crop injury potential. REI: 12-hour. PHI: 70-day.

**Strategy® (ethalfluralin, clomazone)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2-6 pts. per acre. *Direct-seeded:* apply to soil surface within 2 days after seeding. Do not incorporate. *Transplanted:* apply as a banded spray between rows. Does not control large-seeded broadleaves. Needs 0.5 inch of water within 5 days of application to be effective. If no rain occurs, cultivate shallowly. Do not apply over or under hot caps, row covers, or plastic mulch. Do not broadcast over top of plants. Under cool temperatures may cause crop injury or failure. REI: 24-hour. PHI: 45-day.

**trifluralin formulations (trifluralin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Use 4EC formulations at 1-2 pt. per acre. Use 10G formulations at 5-10 lb. per acre. Apply as a directed spray between rows after plants have 3-4 leaves and incorporate 1-2 inches. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour. PHI: 30-day for cantaloupe, cucumber, pumpkin, and squash, 60-day for watermelon.

### **Preemergence Broadleaf Weeds**

**Chateau SW® (flumioxazin)** *Cantaloupe/Muskmelon, Watermelon in Indiana only:* 4 oz. per acre. Applicators must be in possession of 24c and section 3 labels. Indemnified label may be required. Use a shielded or hooded sprayer to apply before transplanting to row middles between plastic mulch-covered raised beds. Bed must be at least 4 inches

higher than treated area and at least 24 inches wide. Spray must remain between raised beds and contact no more than the bottom 1 inch of plastic. Do not apply after crops are transplanted. Rainfall or irrigation over beds is required after application but before transplanting. REI: 12-hour.

**League® (imazosulfuron)** *Cantaloupe/Muskmelon, Watermelon* 4.0-6.4 oz. per acre. Use the higher rate in fields with a known history of yellow nutsedge. Apply between rows after plants are well-established and at least 5 inches wide. Avoid contact with crop and plastic mulch, if present. If emerged weeds are present include a manufacturer-recommended surfactant to control yellow nutsedge and labeled broadleaf weeds that are 1-3 inches tall. Do not exceed 1 application and 6.4 oz. per acre per year. REI: 12-hour. PHI: 48-day.

### **Reflex® (fomesafen) at the following rates:**

*Note: Applicators must have 24c label, when applicable. Illinois label expires Dec 31, 2020. Michigan label expires December 31, 2023. Missouri label expires December 31, 2021. REI: 24-hour.*

*Pumpkin in Illinois and Michigan and Squash in Michigan only:* 8-16 fl. oz. per acre. May be applied as a broadcast or row-middle application after seeding but before emergence on bare ground, or before transplanting on bare ground (up to 7 days prior to transplanting), and as a row middle application that does not contact the plants. An overhead irrigation or rainfall event between Reflex application and transplanting will ensure herbicide activation and will likely reduce the potential for crop injury due to splashing. PHI: 32-day.

*Watermelon in Missouri only:* 10-12 fl. oz. per acre. May be applied after seeding but before emergence on bare ground, before transplanting on bare ground, and both under and over plastic mulch before transplanting at. Up to 16 fl. oz. per acre may be applied as a row middle application that does not contact the plants. PHI: 35-day.

### **Sandeia® (halosulfuron) at the following rates:**

*Cantaloupe/Muskmelon, Cucumber* 0.5-1.0 oz. per acre. *Direct-seed or transplanted on bare ground:* Apply to the soil surface after direct-seeding but prior to cracking or apply at least 7 days before transplanting. Or apply after the crop has been transplanted for a minimum of 14 days and reached the 3-5 true leaf stage, but before the first female flowers appear either over the top or a directed/hooded spray. *Direct-seed or*

## *Herbicides for All Cucurbits<sup>1</sup>*

Product (REI/PHI)	Common Name	Timing and Application		Location Relative to Crop <sup>2</sup>		Weed Groups Controlled	Crops <sup>3</sup>
		Relative to Weeds	Groups Incorporated	Relative to Weeds	Groups Incorporated		
Aim EC® (12h/-)	carfentrazone	X	X	X	X	X	X X X X
Command 3MF® (12h/45d)	clomazone	X	X	X	X	X	X X X X *
Curbit 3EC® (24h/-)	ethalfluralin	X	X	X	X	X	X X X X
Dacthal W-75®, Dacthal Flowable® (12h/-)	DCPA			X	X	X	X X X X
Dual Magnum® (24h/30d)	s-metolachlor	X	X	X	X	X	X X X X
Gramoxone® (12h to 24h/-)	paraquat	X	X	X	X	X	X X X X
League® (12h/48d)	imazosulfuron			X	X	X	X X X X
Poast® (12h/14d)	sethoxydim			X	X	X	X X X X
Prefar 4E® (12h/-)	bensulfide	X	X	yes	X	X	X X X X
Prowl H2O (24h/35d)	pendimethalin		X	X	X	X	X X X X
Roundup®, others (12h/14d)	glyphosate	X	X	X	X	X	X X X X
Sandea® (12h/14d)	halosulfuron	X	X	X	X	X	X X X X
Select Max®, others (12h/14d)	clethodim			X	X	X	X X X X
Sinbar® (12h/70d)	terbacil	X	X	X	X	X	X X X X
Strategy® (24h/ 45d)	clomazone and ethalfluralin	X	X	no	X	X	X X X X
Treflan®, others (12h/30d to 60d)	trifluralin	X	yes	X	X	X	X X X X
	Pumpkin						X X X X
	Squash, winter						X X X X
	Squash, summer						X X X X
	Watermelon						X X X X

<sup>1</sup>For effectiveness against specific weeds, see Relative Effectiveness of Herbicides for Vegetable Crops (page 68), and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbicides can cause serious crop injury and yield loss if not used properly.

$2^X$ =permitted for at least one crop.

<sup>33</sup>X=may be used for that crop. State-specific labels not indicated.  
\*=Processing crops only.

*transplanted into plastic mulch:* Apply to the soil surface after final soil preparation or bed shaping and just before applying plastic mulch. Wait at least 7 days after application and mulch laying before seeding or transplanting. Or apply a minimum of 14 days after transplanting and after the crop has reached the 3-5 true leaf stage, but before the first female flowers appear as a directed/hooded spray. *Row middles on bare ground or plastic mulch:* Apply to row middles avoiding contact with the crop and plastic mulch, if present.

If weeds are present, add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v). Not recommended for use under cool temperatures due to potential for crop injury. May delay crop maturity. Do not exceed 2 applications or 2 oz. per acre per 12-month period. REI: 12-hour. PHI: 30-day for cucumber, 57-day for cantaloupe.

*Pumpkin* 0.5-1.0 oz. per acre. *Direct-seed or transplanted on bare ground* (0.50-0.75 oz. per acre): Apply to the soil surface after direct-seeding but prior to cracking or apply at least 7 days before transplanting. Or apply after the crop has been transplanted for a minimum of 14 days and reached the 2-5 true leaf stage, but before the first female flowers appear either over the top or a directed/hooded spray. *Processing pumpkins:* 0.50-1.0 oz. per acre may be applied. *Row middle application:* Apply 0.5-1.0 oz. per acre between rows. Avoid contact with crop and plastic mulch, if present.

If weeds are present, add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v). Not recommended for use under cool temperatures due to potential for crop injury. May delay crop maturity. Do not exceed 2 applications of 1 oz. per acre or 2 oz. total per 12 month period. REI: 12-hour. PHI: 30-day.

*Summer squash for processing in Missouri only:* 0.5-1.0 oz. per acre. Apply after direct-seeding, but prior to soil cracking or apply between rows of direct-seeded or transplanted summer squash, avoiding contact with the crop. Do not apply more than 2 applications of 1 oz. per acre or 2 oz. per acre per 12 month period. If weeds are present, add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v). REI: 12-hour. PHI: 30-day.

*Watermelon:* 0.5-1.0 oz. per acre. *Direct-seed or transplanted on bare ground in Illinois, Indiana, Kansas, Michigan, Missouri, and Ohio only* (0.50-

0.75 oz. per acre): Apply to the soil surface after direct-seeding but prior to cracking or apply at least 7 days before transplanting. *Direct-seed or transplanted into plastic mulch in Illinois, Indiana, Kansas, Michigan, Missouri, and Ohio only:* Apply to the soil surface after final soil preparation or bed shaping and just before applying plastic mulch. Wait at least 7 days after application and mulch laying before seeding or transplanting. *Row middle application (all states):* Apply 0.5-1.0 oz. per acre between rows. Avoid contact with crop and plastic mulch, if present.

If weeds are present, add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v). Not recommended for use under cool temperatures due to potential for crop injury. May delay crop maturity. Do not exceed 2 applications or 1 oz. per acre per 12-month period. REI: 12-hour. PHI: 57-day.

## Preemergence Grass Weeds

**Dacthal W75® (DCPA)** *Cantaloupe/Muskmelon, Watermelon* Dacthal W-75® at 6-14 lbs. per acre, or Dacthal Flowable® at 6-14 pts. per acre. Apply when plants have 4-5 true leaves and growing conditions favor good plant growth. Crop injury may occur if applied under unfavorable growing conditions or earlier than recommended. REI: 12-hour.

**Prefar 4E® (bensulide)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5-6 qt. per acre. Use low rate on soils with less than 1% organic matter. Apply before planting and incorporate 1-2 in. or apply after seeding before crop emerges and irrigate within 24 hours. REI: 12-hour.

## Postemergence Broadleaf Weeds

**League® (imazosulfuron)** See details in the Preemergence Broadleaf Weeds section of this chapter.

**Reflex® (fomesafen)** See details in the Preemergence Broadleaf Weeds section of this chapter.

**Sandea® (halosulfuron)** See details in the Preemergence Broadleaf Weeds section of this chapter.

## Postemergence Grass Weeds

**clethodim formulations (clethodim)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Use 2 lb. per gal. formulations at 6-8 fl. oz. per acre with 1 qt. COC per 25 gal. of spray solution (1% v/v). Do not exceed 32 fl. oz. per acre per season. Use 0.97 lb. per gal. formulations at 9-16 fl. oz. per acre with 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. per acre per season. Use lower rates for annual grasses

and higher rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 14-day.

**Poast® (sethoxydim)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1-1.5 pt. per acre. Add 1 qt. COC per 25 gal. of spray solution (1% v/v). Spray on actively growing grass. Do not exceed 3 pt. per acre per growing season. REI: 12-hour. PHI: 14-day for squash, pumpkin, and watermelon; 3-day for cantaloupe and cucumber.

## Insect Control

### Recommended Controls

#### Aphids

**Conserve or introduce natural enemies** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Limiting insecticide use will conserve predators and parasites that help control aphid populations. Monitor the presence of predators and parasitized aphids. Several predators per aphid colony will probably bring the aphid population under control without insecticide. Biocontrols are the enemy of the enemy. Some can be purchased and deployed, and other can be conserved through non-crop habitat management and careful pesticide use.

**M-Pede® (potassium salts of fatty acids)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1-2% by volume. Must contact insect to be effective. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Actara® (thiamethoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.5-4 oz. per acre. Do not exceed 11 oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 0-day.

**Admire Pro® (imidacloprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 7-10.5 fl. oz. per acre. See label for various soil application methods. Do not exceed 10.5 fl. oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 21-day.

**Assail 30SG® (acetamiprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.5-4 oz. per acre. Do not exceed 26.5 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Belay® (clothianidin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 3-4 fl. oz. per acre. Use as foliar or soil application. Do not use as foliar after the 4th true leaf on main stem has

unfolded. See pollinator precautions. Do not exceed 12 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day.

**Beleaf 50SG® (flonicamid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2-2.8 oz. per acre. Do no exceed 3 applications per season. REI: 12-hour. PHI: 0-day.

**dimethoate formulations (dimethoate)** *Cantaloupe/Muskmelon, Watermelon* 0.5-1.0 pt. per acre for 400 or 4E formulations. 0.75-1.5 pts. per acre for 2.67EC formulations. REI: see label. PHI: 3-day.

**Exirel® (cyantraniliprole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 13.5-20.5 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Fulfill® (pyrethroid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.75 oz. per acre. Do not exceed 5.5 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Harvanta® (cyclaniliprole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.9-16.4 fl. oz. per acre. Use with adjuvant. Do not exceed 65.6 fl. oz. per acre per year. REI: 4-hour. PHI: 1-day.

**Lannate SP® (methomyl)** *Cantaloupe/Muskmelon, Cucumber, Squash, Watermelon* 0.5-1 lb. per acre. Not for pumpkins or winter squash. REI: 48-hour. PHI: 1-day for 0.5 lb. rate, 3-day for rates over 0.5 lb. RUP.

**malathion formulations (malathion)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5EC formulations use 1.5-2.8 pts. per acre for cucumber and squash, 1.6 pts. per acre for melon, 1.5 pts. per acre for pumpkin, 1.6-2.8 pts. per acre for squash, 1.5-2.5 pts. per acre for watermelon. 57EC formulations use 1.5 pts. per acre on cucumber, melon, pumpkin, squash, and watermelon. 8E formulations use 1.75 pts. per acre for cucumber, 1 pt. per acre for squash. REI: 12-hour for melon, pumpkin, winter squash, and watermelon; 24-hour for cucumber and summer squash. PHI: 1-day.

**Platinum 2SC® (thiamethoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5-11 fl. oz. per acre. See label for application methods. Do not exceed 11 fl. oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 30-day.

**Pounce 25WP® (permethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.4-12.8 oz. per acre. Apply a minimum of 4 gallons finished spray per acre by air, or 20 gallons finished spray per acre with ground equipment. Do not exceed 3.2 lbs. per acre on cantaloupe. Do not exceed 4.8 lbs. per acre for all others. REI: 12-hour. PHI: 0-day. RUP.

**Scorpion 35SL® (dinotefuran)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2-7 fl. oz. per acre. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Sivanto 200SL® (flupyradifurone)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 21-28 fl. oz. per acre soil application, or 7-12 fl. oz. per acre foliar application. REI: 4-hour. PHI: 21-day for soil application, or 1-day for foliar application.

**Venom 70SG® (dinotefuran)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Soil application: 5-7.5 oz. per acre. Do not exceed 12 oz. per acre per season. Foliar application: 1-4 oz. per acre. Do not exceed 6 oz. per acre per season. See pollination precautions. REI: 12-hour. PHI: 21-day for soil application, 1-day for foliar application.

**Verimark® (cyantraniliprole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.0-13.5 fl. oz. per acre. Apply via drip irrigation or soil injection. Do not exceed 30.65 fl. oz. per acre per season, or 2 applications per season. REI: 4-hour. PHI: 1-day.

**Warrior II® (lambda-cyhalothrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.28-1.92 fl. oz. per acre. Do not exceed 11.5 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. RUP.

### **Cucumber Beetles**

Cantaloupe: 1 beetle per plant

Cucumber: 1 beetle per plant

Watermelon: 1 beetle per plant

Squash: 5 beetles per plant

Pumpkin: 5 beetles per plant

The threshold for cantaloupe and cucumber is lower because those crops are susceptible to bacterial wilt, which is vectored by striped cucumber beetles. The threshold for squash and pumpkin is higher because those crops are not as susceptible to bacterial wilt. Watermelons are resistant to bacterial wilt too, but beetles feed on the undersides of fruit.

**Trapping** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Yellow sticky traps are attractive to cucumber beetles and can detect mass emergence to focus

insecticide applications during periods of heavy beetle activity. Use traps to monitor pest populations.

**Actara® (thiamethoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 3-5.5 oz. per acre. Do not exceed 11 oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 0-day.

**Admire Pro® (imidacloprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 7-10.5 fl. oz. per acre. See label for various soil application methods. Do not exceed 10.5 fl. oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 21-day.

**Ambush® (permethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.4-12.8 fl. oz. per acre. Apply a minimum of 4 gals. finished spray per acre by air, or 20 gals. finished spray per acre with ground equipment. Do not exceed 102.4 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. RUP.

**Asana XL® (esfenvalerate)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5.8-9.6 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Assail 30SG® (acetamiprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.5-5.3 oz. per acre. Do not exceed 26.5 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Azera® (azadirachtin, pyrethrins)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 48 fl. oz. per acre. Do not exceed 10 applications per season. Do not reapply within 3 days except under extreme pest pressure. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Baythroid XL® (beta-cyfluthrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.4-4.8 fl. oz. per acre. Do not exceed 11.2 fl. oz. per acre or 4 applications per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day. RUP.

**Belay® (clothianidin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 3-4 fl. oz. per acre. Use as foliar or soil application. Do not use as foliar after the 4th true leaf on main stem has unfolded. See pollinator precautions. Do not exceed 12 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day.

**Brigade 2EC® (bifenthrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.6-6.4 fl. oz. per acre. Do not exceed 19.2 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Danitol 2.4EC® (fenpropathrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.67-16 fl. oz. per acre. Do not exceed 42.67 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. RUP.

**Harvanta® (cyclaniliprole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.9-16.4 fl. oz. per acre. Do not exceed 65.6 fl. oz. per acre per year. REI: 4-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.8-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. RUP.

**Pounce 25WP® (permethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.4-12.8 oz. per acre. Apply a minimum of 4 gallons finished spray per acre by air, or 20 gallons finished spray per acre with ground equipment. Do not exceed 3.2 lbs. per acre on cantaloupe. Do not exceed 4.8 lbs. per acre for all others. REI: 12-hour. PHI: 0-day. RUP.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Seed treatments containing thiamethoxam provide control.

**Sevin XLR Plus® (carbaryl)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1 qt. per acre. When applied during hot, humid conditions, carbaryl may cause some phytotoxicity, especially on seedlings and newly set plants. See pollinator precautions. Do not exceed 6 qts. per acre per season. REI: 12-hour. PHI: 3-day.

**Warrior II® (lambda-cyhalothrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.28-1.92 fl. oz. per acre. Do not exceed 11.5 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. RUP.

### **Leafhoppers**

**Admire Pro® (imidacloprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 7-10.5 fl. oz. per acre. See label for various soil application methods. Do not exceed 10.5 fl. oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 21-day.

**Ambush® (permethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.4-12.8 fl. oz. per acre. Apply a minimum of 4 gals. finished spray per acre by air, or 20 gals. finished spray per acre with ground equipment. Do not exceed 102.4 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. RUP.

**Asana XL® (esfenvalerate)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5.8-9.6 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Assail 30SG® (acetamiprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.5-4 oz. per acre. Do not exceed 26.5 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Baythroid XL® (beta-cyfluthrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 0.8-1.6 fl. oz. per acre. Do not exceed 11.2 fl. oz. per acre or 4 applications per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day. RUP.

**Belay® (clothianidin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 3-4 fl. oz. per acre. Use as foliar or soil application. Do not use as foliar after the 4th true leaf on main stem has unfolded. See pollinator precautions. Do not exceed 12 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day.

**Brigade 2EC® (bifenthrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.6-6.4 fl. oz. per acre. Do not exceed 19.2 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**dimethoate formulations (dimethoate)** *Cantaloupe/Muskmelon, Watermelon* 0.5-1.0 pt. per acre for 400 or 4E formulations. 0.75-1.5 pts. per acre for 2.67EC formulations. REI: see label. PHI: 3-day.

**Platinum 2SC® (thiamethoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5-11 fl. oz. per acre. See label for application methods. Do not exceed 11 fl. oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 30-day.

**Pounce 25WP® (permethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.4-12.8 oz. per acre. Apply a minimum of 4 gallons finished spray per acre by air, or 20 gallons finished spray per acre with ground equipment. Do not exceed 3.2 lbs. per acre on cantaloupe. Do not exceed 4.8 lbs. per acre for all others. REI: 12-hour. PHI: 0-day. RUP.

**Sivanto 200SL® (flupyradifurone)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 21-28 fl. oz. per acre soil application, or 7-12 fl. oz. per acre foliar application. REI: 4-hour. PHI: 21-day for soil application, or 1-day for foliar application.

**Venom 70SG® (dinotefuran)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Soil application: 5-7.5 oz. per acre. Do not exceed 12 oz. per acre per season. Foliar application: 1-4 oz. per acre. Do not exceed 6 oz. per acre per season. See pollination precautions. REI: 12-hour. PHI: 21-day for soil application, 1-day for foliar application.

**Warrior II® (lambda-cyhalothrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.28-1.92 fl. oz. per acre. Do not exceed 11.5 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. RUP.

## Mites

**abamectin formulations (abamectin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 8-16 fl. oz. per acre for 0.15EC formulations. 1.75-3.5 fl. oz. per acre for SC formulations. Allow at least 7 days between applications. Do not make more than 2 sequential applications. Do not exceed 48 fl. oz. per acre per season for 0.15EC formulations. Do not exceed 10.25 fl. oz. per acre per season for SC formulations. REI: 12-hour. PHI: 7-day. RUP.

**Acramite 50WS® (bifenazate)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 0.75-1 lb. per acre. One application per season. REI: 12-hour. PHI: 3-day.

**Brigade 2EC® (bifenthrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5.12-6.4 fl. oz. per acre. Do not exceed 19.2 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Danitol 2.4EC® (fenpropathrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.67-16 fl. oz. per acre. Do not exceed 42.67 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. RUP.

**Kanemite 15SC® (acequinocyl)** *Cantaloupe/Muskmelon, Cucumber, Watermelon* 31 fl. oz. per acre. Do not exceed 2 applications per year. Allow 21 days between applications. REI: 12-hour. PHI: 1-day.

**Oberon 2SC® (spiromesifen)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 7.0-8.5 fl. oz. per acre. Do not exceed 3 applications per season. REI: 12-hour. PHI: 7-day.

**Portal® (fenpyroximate)** *Cantaloupe/Muskmelon, Cucumber* 2 pts. per acre. Do not exceed 2 applications per season. REI: 12-hour. PHI: 1-day for cucumber, 3-day for melon.

**Zeal® (etoxazole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2-3 oz. per acre. Do not exceed 1 application per season. REI: 12-hour. PHI: 7-day.

## Seed and Root Maggots

**Moldboard plow** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Early plowing of cover crops and weeds will generally result in less damage to seedling plants in field. Plowing can eliminate emerged annual weeds by turning soil.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Seed treatments containing thiamethoxam provide control.

**Verimark® (cyantraniliprole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.0-13.5 fl. oz. per acre. Apply via drip irrigation or soil injection. Do not exceed 30.65 fl. oz. per acre per season, or 2 applications per season. REI: 4-hour. PHI: 1-day.

## Squash Bug

**Ambush® (permethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.4-12.8 fl. oz. per acre. Apply a minimum of 4 gals. finished spray per acre by air, or 20 gals. finished spray per acre with ground equipment. Do not exceed 102.4 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. RUP.

**Asana XL® (esfenvalerate)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5.8-9.6 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Assail 30SG® (acetamiprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.5-5.3 oz. per acre. Do not exceed 26.5 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Azera® (azadirachtin, pyrethrins)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 32-48 fl. oz. per acre. Use higher rates for squash bug adults, or when pest pressure is extreme of plant canopy is dense. Do not exceed 10 applications per season. Do not reapply within 3 days except under extreme pest pressure. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Belay® (clothianidin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 3-4 fl. oz. per acre. Use as foliar or soil application. Do not use as foliar after the 4th true leaf on main stem has unfolded. See pollinator precautions. Do not exceed 12 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day.

**Brigade 2EC® (bifenthrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.6-6.4 fl. oz. per acre. Do not exceed 19.2 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Harvanta® (cyclaniliprole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.9-16.4 fl. oz. per acre. Do not exceed 65.6 fl. oz. per acre per year. REI: 4-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.8-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. RUP.

**Pounce 25WP® (permethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.4-12.8 oz. per acre. Apply a minimum of 4 gallons finished spray per acre by air, or 20 gallons finished spray per acre with ground equipment. Do not exceed 3.2 lbs. per acre on cantaloupe. Do not exceed 4.8 lbs. per acre for all others. REI: 12-hour. PHI: 0-day. RUP.

**Sevin XLR Plus® (carbaryl)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1 qt. per acre. When applied during hot, humid conditions, carbaryl may cause some phytotoxicity, especially on seedlings and newly set plants. See pollinator precautions. Do not exceed 6 qts. per acre per season. REI: 12-hour. PHI: 3-day.

**Venom 70SG® (dinotefuran)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Soil application: 5-7.5 oz. per acre. Do not exceed 12 oz. per acre per season. Foliar application: 1-4 oz. per acre. Do not exceed 6 oz. per acre per season. See pollination precautions. REI: 12-hour. PHI: 21-day for soil application, 1-day for foliar application.

**Warrior II® (lambda-cyhalothrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.28-1.92 fl. oz. per acre. Do not exceed 11.5 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. RUP.

### **Squash Vine Borer**

**Trapping** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Pheromone-bated traps are attractive to squash vine borers and can detect mass flights to focus insecticide applications during periods of heavy egg-laying activity. Use traps to monitor pest populations.

**Ambush® (permethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.4-12.8 fl. oz. per acre. Apply a minimum of 4 gals. finished spray per acre by air, or 20 gals. finished spray per acre with ground equipment. Do not exceed 102.4 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. RUP.

**Asana XL® (esfenvalerate)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5.8-9.6 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Assail 30SG® (acetamiprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.5-5.3 oz. per acre. Do not exceed 26.5 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Brigade 2EC® (bifenthrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.6-6.4 fl. oz. per acre. Do not exceed 19.2 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Mustang Maxx® (zeta-cypermethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.8-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. RUP.

**Pounce 25WP® (permethrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6.4-12.8 oz. per acre. Apply a minimum of 4 gallons finished spray per acre by air, or 20 gallons finished spray per acre with ground equipment. Do not exceed 3.2 lbs. per acre on cantaloupe. Do not exceed 4.8 lbs. per acre for all others. REI: 12-hour. PHI: 0-day. RUP.

**Warrior II® (lambda-cyhalothrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1.28-1.92 fl. oz. per acre. Do not exceed 11.5 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. RUP.

### **Thrips**

**Admire Pro® (imidacloprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 7-10.5 fl. oz. per acre. See label for various soil application methods. Do not exceed 10.5 fl. oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 21-day.

**Entrust® (spinosad)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6-8 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day for cucumber, 3-day for all others. OMRI-listed.

**Harvanta® (cyclaniliprole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.9-16.4 fl. oz. per acre. Do not exceed 65.6 fl. oz. per acre per year. REI: 4-hour. PHI: 1-day.

**Platinum 2SC® (thiamethoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5-11 fl. oz. per acre. See label for application methods. Do not exceed 11 fl. oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 30-day.

**Radiant 1SC® (spinetoram)** *Cantaloupe/Muskmelon, Pumpkin, Squash, Watermelon* 6-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 3-day.

**Radiant 1SC® (spinetoram)** *Cucumber* 6-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

### Whiteflies

**M-Pede® (potassium salts of fatty acids)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 1-2% by volume. Must contact insect to be effective. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Neemix® (azadirachtin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 6-16 fl. oz. per acre. REI: 4-hour. PHI: 0-day. OMRI-listed.

**Actara® (thiamethoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 3-5.5 oz. per acre. Do not exceed 11 oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 0-day.

**Admire Pro® (imidacloprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 7-10.5 fl. oz. per acre. See label for various soil application methods. Do not exceed 10.5 fl. oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 21-day.

**Assail 30SG® (acetamiprid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.5-5.3 oz. per acre. Do not exceed 26.5 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Beleaf 50SG® (flonicamid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2-8 oz. per acre. Do not exceed 3 applications per season. REI: 12-hour. PHI: 0-day.

**Brigade 2EC® (bifenthrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5.12-6.4 fl. oz. per acre. Do not exceed 19.2 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Exirel® (cyantraniliprole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 13.5-20.5 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Fulfill® (pyrethroid)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2.75 oz. per acre. Do not exceed 5.5 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Knack® (pyriproxyfen)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 8-10 fl. oz. per acre. Do not exceed 2 applications. REI: 12-hour. PHI: 7-day.

**Oberon 2SC® (spiromesifen)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 7.0-8.5 fl. oz. per acre. Do not exceed 3 applications per season. REI: 12-hour. PHI: 7-day.

**Platinum 2SC® (thiamethoxam)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 5-11 fl. oz. per acre. See label for application methods. Do not exceed 11 fl. oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 30-day.

**Scorpion 35SL® (dinotefuran)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 2-7 fl. oz. per acre. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Sivanto 200SL® (flupyradifurone)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 21-28 fl. oz. per acre soil application, or 7-12 fl. oz. per acre foliar application. REI: 4-hour. PHI: 21-day for soil application, or 1-day for foliar application.

**Venom 70SG® (dinotefuran)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* Soil application: 5-7.5 oz. per acre. Do not exceed 12 oz. per acre per season. Foliar application: 1-4 oz. per acre. Do not exceed 6 oz. per acre per season. See pollination precautions. REI: 12-hour. PHI: 21-day for soil application, 1-day for foliar application.

**Verimark® (cyantraniliprole)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 10.0-13.5 fl. oz. per acre. Apply via drip irrigation or soil injection. Do not exceed 30.65 fl. oz. per acre per season, or 2 applications per season. REI: 4-hour. PHI: 1-day.

### Wireworms

**Capture LFR® (bifenthrin)** *Cantaloupe/Muskmelon, Cucumber, Pumpkin, Squash, Watermelon* 0.2-0.39 fl. oz. per 1,000 linear ft. of row. Do not exceed 8.5 fl. oz. per acre per season. REI: 12-hour. RUP.

# Fruiting Vegetables

## Transplants

Eggplant, peppers, and tomatoes are typically started as transplants in greenhouses or artificially lit growing rooms — refer to Transplant Production, page 23.

For rapid seed germination, maintain the temperature of potting mix at 85°F. Grow eggplant seedlings between 70°F and 80°F during the day and 65°F and 70°F at night, and tomatoes and peppers between 65°F and 75°F during the day and 60°F and 65°F at night.

Pepper and eggplant seedlings should be ready for the field in six to eight weeks and tomatoes in five to seven weeks.

Before transplanting, harden seedlings by exposing them for a few days to higher light and temperatures between 60°F and 65°F. Set tomatoes in the field after the danger of frost has passed. For peppers and eggplant, wait until soil has warmed and average daily temperature reach 65°F.

## Production Systems for Fresh Market

Fresh market eggplant, peppers, and tomatoes are often grown on raised beds covered with plastic mulch to promote earliness — see Using Plastic Mulch, page 27. Drip irrigation beneath the mulch provides a uniform water supply and can deliver fertilizer during the growing season. Typical beds are 30 inches across, 4 to 6 inches high, and centered 5 to 6 feet apart.

**Tomatoes and eggplant:** Space 1.5 to 2.5 feet apart in the row.

**Peppers:** Space 1 to 1.5 feet apart. Or, plant a double row of peppers with 1.5 feet between rows and 1 foot between plants.

**Bare ground culture:** Space rows 2.5 to 5 feet apart.

*Tomatoes and eggplants:* space 1.5 to 3 feet apart in the row. *Peppers:* space 1 to 1.5 feet apart in the row.

**Tomatoes** may be left to grow over the ground or may be supported by cages, stakes, strings, or a trellis-weave system. Supported tomatoes produce higher quality fruit than unsupported plants and marketable yield is usually much greater. Tomatoes supported by stakes or trellises are sometimes pruned, which involves removing several or all of the branches up to the branch just below the first flower cluster when the branches are a few inches long. For tomatoes supported by vertical string, only one or

two stems are allowed to grow and so pruning continues throughout the season to remove branches that develop above the first flower cluster. Pruned plants produce larger fruit than unpruned plants, but the quantity of fruit is reduced.

**Peppers and eggplant** may benefit from staking if plants tend to break, lean, or lodge. If peppers are in a double row on a bed, a row of short stakes strung with twine along the outside of each row will support the plants. Peppers and eggplant may also be supported using a trellis-weave system.

## Production Systems for Processing Tomatoes

Select row spacing and bed formation that will work with available harvesting equipment. Double rows 16 to 20 inches apart on 5 to 6 feet centers are common, with plants 1 to 2 feet apart in the row.

Ethepron applications accelerate and concentrate fruit ripening, thus facilitating once-over machine harvesting of processing tomatoes.

**For Machine Harvest:** Apply 3.25 pts. Ethrel® or Cepha® in 5 to 70 gallons of water per acre as a spray over the entire plant when 10 to 30 percent of fruits are ripe. Harvest 15 to 21 days after treatment for optimum ripe fruit accumulation.

## Fertilizing

**Lime:** To maintain a soil pH of 6.0 to 6.8.

**Fresh Market Eggplant, Peppers, and Tomatoes:** Before planting, apply 30 pounds N per acre, 0 to 240 pounds per acre P<sub>2</sub>O<sub>5</sub>, and 0 to 300 pounds K<sub>2</sub>O per acre based on soil test results and recommendations from your state. At transplanting, apply a starter solution containing N and P. If the transplant flat received a heavy fertilizer feeding just prior to setting, eliminate the starter solution. Three to four weeks after transplanting, and then six to eight weeks after transplanting, apply 30 to 40 pounds N per acre as a sidedressing. Sidedressing may be replaced by supplying N through the drip irrigation system at about 1 pound N per acre per day. Reduce the amount of fertilizer N applied by the value of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and

soils with more than 3 percent organic matter. The total amount of N from fertilizer (including starter) and other credits should be 100 to 120 pounds per acre. K<sub>2</sub>O may also be supplied through drip irrigation at a rate of 1 to 1.5 pounds per acre per day for peppers and eggplant, and 1.5 to 2.5 pounds per acre per day for tomatoes. Reduce the amount of K<sub>2</sub>O applied before planting by the amount that will be supplied through drip irrigation.

**Processing Tomatoes:** Before planting, apply 40 pounds N per acre, and P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O based on soil test results and recommendations from your state. At transplanting, apply a starter solution containing N and P. Four to five weeks after transplanting or after first fruit, set sidedress with 40 to 50 pounds N per acre. Reduce the amount of fertilizer N applied by the amount of N credits from green manures, legume crops grown in the previous year, compost and animal manures, and soils with more than 3 percent organic matter. The total amount of N from fertilizer (including starter) and other credits should be 80 to 100 pounds per acre.

**Calcium:** Tomatoes and peppers are susceptible to calcium deficiency even when adequate calcium levels are present in the soil. Deficiency results in a disorder called "blossom end rot." It often occurs under conditions of inadequate or excessive watering and/or excessive N fertilization with an ammonium source. Where the soil pH has been adjusted to 6.0 or higher, additional soil-applied calcium does not correct the disorder.

## Environmental Factors

There are a number of tomato problems related to environmental and nutrient factors.

**Sunscald:** Fruit exposed to the sun may overheat and develop sunscald. The affected area turns white and does not ripen. The tissue may shrivel and sink in. It is most common when foliage does not shade fruit exposed to hot afternoon sun. Damage is usually confined to the area of the fruit with greatest exposure to the sun. Tomato variety, mineral nutrition, staking and pruning methods, and disease pressure can all influence the amount of foliage cover. This disorder also is observed on peppers and fruit of other vegetable crops.

**Radial and concentric cracks:** Rapidly growing fruit and fruit exposed to the sun tend to crack more readily. Cracking is more severe under hot, dry conditions followed by rainfall. To defend against growth cracks, select crack-resistant cultivars and carefully manage water availability (through irrigation management and the use of plastic mulch).

**Zipper scars:** These may be caused when the blossom sticks to the developing fruit. Zipper scars are especially common during cool weather. To avoid this problem, select resistant varieties and maintain proper greenhouse temperatures.

**Catfacing:** Flower buds that have been exposed to cold temperatures very early in development have shown a higher proportion of catfaced fruit. Large-fruited varieties tend to be more susceptible to this disorder. In some heirloom varieties, nearly all fruit is catfaced so it does not detract from the fruit's marketability. Variety selection is the most practical way to limit this problem. Exposure to some herbicides (2, 4-D or dicamba) can lead to similar fruit deformation.

**Micro-cracks or rain checks:** Very small cracks in the epidermis (called micro-cracks or rain checks) sometimes develop on fruit shoulders under highly humid conditions. Rain check is often more severe on fruit that has been exposed due to poor leaf cover. To minimize the problem, maintain healthy foliage and select varieties with good foliage cover.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### ***Anthracnose of Fruiting Vegetables - Colletotrichum Fungus***

Symptoms usually occur on ripe or over-ripe fruit. Winter/off-season: Rotate crops at least 2-3 years and practice fall tillage. Fruit set: Begin fungicide applications at or shortly before fruit set. Harvest: Inspect fruit for lesions.

#### ***Serenade ASO® (Bacillus subtilis strain QST-713)***

*Pepper, Tomato* 2-4 qts. per acre. Substitute up to two fungicide applications in program. REI: 4-hour. PHI: 0-day. OMRI-listed.

#### ***Serenade Opti® (Bacillus subtilis strain QST-713)***

*Pepper, Tomato* 14-20 oz. per acre. May help bacterial spot management when copper-resistant strains are present. REI: 4-hour. PHI: 0-day. OMRI-listed.

#### ***Aprovia Top® (difenoconazole, benzovindiflupyr (solatenol))***

*Eggplant, Pepper, Tomato* 10.5-13.5 fl. oz. per acre. Use of a spreader sticker is recommended. REI: 12-hour. PHI: 0-day.

#### ***Cabrio EG® (pyraclostrobin)*** *Pepper, Tomato* 8-12 oz. per acre. REI: 12-hour. PHI: 0-day.

**chlorothalonil formulations (chlorothalonil) Pepper, Tomato** See label. Several chlorothalonil formulations (e.g., Bravo®, Echo®, and Equus®) are labeled for use at various rates. REI: 12-hour. PHI: 0-day.

**Fontelis® (pentylopyrad) Pepper, Tomato** 24 fl. oz. per acre. See label for greenhouse uses. Suppression only for anthracnose. REI: 12-hour. PHI: 0-day.

**Inspire Super® (difenoconazole, cyprodinil) Pepper, Tomato** 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day.

**Luna Sensation® (fluopyram, trifloxystrobin) Pepper, Tomato** 7.6 fl. oz. per acre. Suppression only for anthracnose and white mold. REI: 12-hour. PHI: 3-day.

**mancozeb formulations (mancozeb) Pepper, Tomato** See label. Several mancozeb formulations (e.g., Dithane®, Manzate®, Penncozeb®, Roper®) are labeled for use at various rates. REI: 24-hour. PHI: 5-day.

**Orondis Opti Premix® (oxathiapiprolin, chlorothalonil) Pepper, Tomato** 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day.

**Priaxor® (fluxapyroxad, pyraclostrobin) Pepper, Tomato** 4-8 fl. oz. per acre. Suppression only for Botrytis gray mold and white mold. REI: 12-hour. PHI: 0-day.

**Quadris 2.08SC® (azoxystrobin) Pepper, Tomato** 5-6.2 fl. oz. per acre. REI: 4-hour. PHI: 0-day.

**Quadris Opti® (azoxystrobin, chlorothalonil) Pepper, Tomato** 1.6 pts. per acre. REI: 12-hour. PHI: 0-day.

**Quadris Top® (azoxystrobin, difenoconazole) Pepper, Tomato** 8-14 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Revus Top® (mandipropamid, difenoconazole) Pepper, Tomato** 5.5-7 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day.

**Tanos® (famoxadone, cymoxanil) Pepper, Tomato** 8 oz. per acre. For late blight, tank-mix with a contact fungicide with a different mode of action. Disease suppression for bacterial diseases. REI: 12-hour. PHI: 3-day.

### ***Bacterial Canker of Tomatoes - *Clavibacter* Bacteria***

The bacterium becomes systemic in the plant causing wilt and leaf/fruit/stem lesions.

Use disease-free seed and transplants. The transplant facility treatments listed for Bacterial Spot/Specck (below)

will help reduce the severity of bacterial canker. However, copper applications in the field are generally ineffective for controlling canker.

Fields with a history of canker should be planted to crops other than tomato, potato, pepper, or eggplant for at least 3 years. Sanitize machinery, seedlings, and plant production materials (transplant trays, greenhouse benches, and wooden stakes) with a disinfectant such as 10% chlorine bleach or a quaternary ammonium compound solution. Avoid working in wet fields.

**Winter/off-season:** Rotate crops at least 3 years and practice fall tillage. The pathogen is seedborne. Consider seed treatment with hot water or dilute chlorine bleach (see Seed Treatments, page 26).

**Greenhouse:** Inspect seedlings for disease and apply one or two fixed copper product applications. Tank-mix copper product with mancozeb (see bacterial spot/specck below).

**Planting:** Do not plant seedlings that have symptoms of bacterial canker.

**Fruit Set:** Inspect plants for symptoms of bacterial canker.

**Harvest:** Inspect fruit. Avoid saving seed.

**Tanos® (famoxadone, cymoxanil) Pepper, Tomato** 8 oz. per acre. For late blight, tank-mix with a contact fungicide with a different mode of action. Disease suppression for bacterial diseases. REI: 12-hour. PHI: 3-day.

### ***Bacterial Speck of Tomatoes - *Pseudomonas* Bacteria***

**Regalia® (Reynoutria sachalinensis) Pepper, Tomato** 1-4 qts. per acre. Use in a program with copper products. REI: 4-hour. PHI: 0-day. OMRI-listed.

**Serenade ASO® (Bacillus subtilis strain QST-713) Pepper, Tomato** 2-4 qts. per acre. Substitute up to two fungicide applications in program. REI: 4-hour. PHI: 0-day. OMRI-listed.

**Serenade Opti® (Bacillus subtilis strain QST-713) Pepper, Tomato** 14-20 oz. per acre. May help bacterial spot management when copper-resistant strains are present. REI: 4-hour. PHI: 0-day. OMRI-listed.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Pepper, Tomato* See label. Several formulations of copper products e.g., Badge®, Champ®, Cueva®, Cuprofix®, Kentan®, Kocide®, Nordox®) are labeled for use. Copper-resistant strains are common in the Midwest. Mancozeb products (e.g., Dithane®, Manzate®, Penncozeb®, Roper®) when tank-mixed with copper products, allow more copper to become available on the leaf surface and so may help manage copper-resistant bacterial strains. REI: see label. PHI: 0-day.

**Tanos® (famoxadone, cymoxanil)** *Pepper, Tomato* 8 oz. per acre. For late blight, tank-mix with a contact fungicide with a different mode of action. Disease suppression for bacterial diseases. REI: 12-hour. PHI: 3-day.

#### ***Bacterial Spot of Tomatoes/Peppers - Xanthomonas Bacteria***

Lesions of this disease can be found on leaves, stems, and fruit. Use disease-free seed and/or transplants.

**Copper Resistance:** Strains of the bacterium that cause bacterial spot on tomato that are resistant to copper products are common in the Midwest. Actigard®, Agri-mycin 17®, mancozeb products, Tanos®, and Serenade Max® used as labeled may help manage copper-resistant strains.

**Winter/Off-season:** Rotate crops at least 2 years and practice fall tillage. Purchase seed tested for these diseases. Consider seed treatment with hot water or dilute Clorox (see Seed Treatments, page 26).

**Greenhouse:** Scout and apply fixed copper alternated with streptomycin (Agri-mycin 17®, Firewall 17WP®, Streptrol®).

**Planting:** Do not plant seedlings with symptoms of bacterial spot/speck. Apply fixed copper product tank-mixed with mancozeb on 7-10 day schedule, depending on disease pressure, beginning within 1 week after transplanting.

**Harvest:** Inspect fruit. Avoid saving seed.

**Regalia® (Reynoutria sachalinensis)** *Pepper, Tomato* 1-4 qts. per acre. Use in a program with copper products. REI: 4-hour. PHI: 0-day. OMRI-listed.

**Serenade ASO® (Bacillus subtilis strain QST-713)** *Pepper, Tomato* 2-4 qts. per acre. Substitute up to two fungicide applications in program. REI: 4-hour. PHI: 0-day. OMRI-listed.

#### **Serenade Opti® (Bacillus subtilis strain QST-713)**

*Pepper, Tomato* 14-20 oz. per acre. May help bacterial spot management when copper-resistant strains are present. REI: 4-hour. PHI: 0-day. OMRI-listed.

**Actigard® (acibenzolar-s-methyl)** *Pepper, Tomato* 0.3-0.75 oz. per acre. Begin season with lower rates and increase as plant canopy increases. Do not exceed 6 oz. per season. REI: 12-hour. PHI: 14-day.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Pepper, Tomato* See label. Several formulations of copper products e.g., Badge®, Champ®, Cueva®, Cuprofix®, Kentan®, Kocide®, Nordox®) are labeled for use. Copper-resistant strains are common in the Midwest. Mancozeb products (e.g., Dithane®, Manzate®, Penncozeb®, Roper®) when tank-mixed with copper products, allow more copper to become available on the leaf surface and so may help manage copper-resistant bacterial strains. REI: see label. PHI: 0-day.

#### **streptomycin formulations (Streptomycin sulfate)**

*Pepper, Tomato* See label. Agrimycin 17®, Firewall 17WP®, and Streptrol® are labeled at various rates. Apply one or two times to seedlings, alternated with a fixed copper product compound (see below) beginning at the two-leaf stage. Not labeled for use after transplanting (greenhouse only). REI: 12-hour. PHI: NA

**Tanos® (famoxadone, cymoxanil)** *Pepper, Tomato* 8 oz. per acre. For late blight, tank-mix with a contact fungicide with a different mode of action. Disease suppression for bacterial diseases. REI: 12-hour. PHI: 3-day.

#### ***Buckeye Rot of Tomatoes - Phytophthora Fungus***

These diseases are favored by heavy rains and waterlogged soils. Symptoms include discolored fruit and declining plants.

Rotate away from tomato, pepper, vine crops, or snap beans for 3 years. Avoid low areas of fields. Plastic mulch may reduce splash infection.

**Winter/Off-season:** Rotate crops at least every 3 years and practice fall tillage. Avoid poorly drained soils. Use raised beds. Mulch may lessen buckeye rot's impact.

**Planting:** Consider fungicide drench. Regular fungicide schedule may lessen impact of buckeye rot.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Tomato* See label. Fixed copper products may improve efficacy of fungicides against Phytophthora blight when tank mixed at labeled rates. REI: see label. PHI: 0-day.

**Gavel 75DF® (zoxamide, mancozeb)** *Tomato* 1.5-2 lbs. per acre. REI: 48-hour. PHI: 5-day.

**Orondis Opti Premix® (oxathiapiprolin, chlorothalonil)** *Pepper, Tomato* 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day.

**Orondis Ultra Premix® (oxathiapiprolin, mandipropamid)** *Tomato* 5.5-8 fl. oz. per acre. Alternate with fungicides that have a different mode of action. REI: 4-hour. PHI: 1-day.

**Quadris 2.08SC® (azoxystrobin)** *Pepper, Tomato* 5-6.2 fl. oz. per acre. REI: 4-hour. PHI: 0-day.

**Quadris Opti® (azoxystrobin, chlorothalonil)** *Pepper, Tomato* 1.6 pts. per acre. REI: 12-hour. PHI: 0-day.

**Ridomil Gold Copper® (mefenoxam, copper hydroxide)** *Tomato* See label. Rates and PHI vary depending on whether crop is processing or fresh market tomato. REI: 48-hour. PHI: See label.

**Tanos® (famoxadone, cymoxanil)** *Pepper, Tomato* 8 oz. per acre. For late blight, tank-mix with a contact fungicide with a different mode of action. Disease suppression for bacterial diseases. REI: 12-hour. PHI: 3-day.

### **Early Blight of Tomatoes - *Alternaria* Fungus**

This disease initially cause lesions on lower leaves of the tomato plant. Plant resistant varieties. Use wilt resistant "VF" cultivars, and avoid fields with a wilt history. Tomato plants weakened by wilt disease may be more prone to leaf blights. Practice 3-4-year rotation with unrelated crops. Rotate out of fields with a history of early blight or Septoria leaf spot.

**Group 11 Resistance:** Strains of the fungus that causes early blight that are resistant to group 11 fungicides have been observed in Indiana and Ohio. Group 11 products labeled for tomato and early blight include Cabrio® and Quadris®. Tank-mix group 11 fungicides with products that have a different mode of action, or alternate group 11 fungicides with fungicides that have a different group number. See Selected Information About Recommended Fungicides (page 79) for more information.

**Winter/Off-season:** Use crop rotations of at least 3-4 years for early blight.

**Planting:** Begin protective fungicide applications on a 7-14 day schedule.

**Variety selection** *Tomato* Select crop varieties for competitiveness, disease resistance, and regional adaptability.

**Aprovia Top® (difenoconazole, benzovindiflupyr (solatenol))** *Eggplant, Pepper, Tomato* 10.5-13.5 fl. oz. per acre. Use of a spreader sticker is recommended. REI: 12-hour. PHI: 0-day.

**Cabrio EG® (pyraclostrobin)** *Pepper, Tomato* 8-12 oz. per acre. REI: 12-hour. PHI: 0-day.

**chlorothalonil formulations (chlorothalonil)** *Pepper, Tomato* See label. Several chlorothalonil formulations (e.g., Bravo®, Echo®, and Equus®) are labeled for use at various rates. REI: 12-hour. PHI: 0-day.

**Endura® (boscalid)** *Pepper, Tomato* 2.5-3.5 oz. per acre. REI: 12-hour. PHI: 0-day.

**Fontelis® (penthiopyrad)** *Pepper, Tomato* 16-24 fl. oz. per acre. See label for greenhouse uses. REI: 12-hour. PHI: 0-day.

**Inspire Super® (difenoconazole, cyprodinil)** *Pepper, Tomato* 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** *Pepper, Tomato* 5-7.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**Luna Tranquility® (fluopyram, pyrimethanil)** *Pepper, Tomato* 11.2 fl. oz. per acre. Disease suppression of powdery mildew. REI: 12-hour. PHI: 1-day.

**mancozeb formulations (mancozeb)** *Pepper, Tomato* See label. Several mancozeb formulations (e.g., Dithane®, Manzate®, Penncozeb®, Roper®) are labeled for use at various rates. REI: 24-hour. PHI: 5-day.

**Miravis Prime® (pydiflumetofen, fludioxonil)** *Pepper, Tomato* 9.2-11.4 fl. oz. per acre. Use high rate for gray mold, suppression only. REI: 12-hour. PHI: 0-day.

**Priaxor® (fluxapyroxad, pyraclostrobin)** *Pepper, Tomato* 4-8 fl. oz. per acre. Suppression only for Botrytis gray mold and white mold. REI: 12-hour. PHI: 0-day.

**Quadris 2.08SC® (azoxystrobin)** *Pepper, Tomato* 5-6.2 fl. oz. per acre. REI: 4-hour. PHI: 0-day.

*OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.*

**Quadris Opti® (azoxystrobin, chlorothalonil) Pepper,**  
*Tomato* 1.3-1.6 pts. per acre. REI: 12-hour. PHI: 0-day.

**Revus Top® (mandipropamid, difenoconazole) Pepper,**  
*Tomato* 5.5-7 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day.

**Switch 62.5WG® (cyprodinil, fludioxonil) Pepper,**  
*Tomato* 11-14 oz. per acre. Do not apply to small-fruited varieties in the greenhouse. REI: 12-hour. PHI: 0-day.

**Tanos® (famoxadone, cymoxanil) Pepper, Tomato** 6-8 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

### **Fusarium wilt of tomato**

**Variety selection** *Tomato* Select crop varieties for competitiveness, disease resistance, and regional adaptability.

### **Gray Mold of Multiple Crops - Botrytis Fungus**

**Botran 75W® (dichloro-nitroaniline) Pepper, Tomato** 1 lb. per 100 gals. of water. Labeled for stem phase of gray mold. Apply to stems up to a height of 24 inches. Young plants may be injured. REI: see label. PHI: 0-day.

**Cabrio EG® (pyraclostrobin) Pepper, Tomato** 12-16 oz. per acre. Suppression only for Botrytis gray mold and white mold. REI: 12-hour. PHI: 0-day.

**chlorothalonil formulations (chlorothalonil) Pepper, Tomato** See label. Several chlorothalonil formulations (e.g., Bravo®, Echo®, and Equus®) are labeled for use at various rates. REI: 12-hour. PHI: 0-day.

**Endura® (boscalid) Pepper, Tomato** 9-12.5 oz. per acre. Suppression only. REI: 12-hour. PHI: 0-day.

**Fontelis® (pentiopyrad) Pepper, Tomato** 16-24 fl. oz. per acre. See label for greenhouse uses. REI: 12-hour. PHI: 0-day.

**Inspire Super® (difenoconazole, cyprodinil) Pepper, Tomato** 16-20 fl. oz. per acre. Do not apply to small-fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day.

**Luna Sensation® (fluopyram, trifloxystrobin) Pepper, Tomato** 7.6 fl. oz. per acre. Suppression only for anthracnose and white mold. REI: 12-hour. PHI: 3-day.

**Luna Tranquility® (fluopyram, pyrimethanil) Pepper, Tomato** 11.2 fl. oz. per acre. Disease suppression of powdery mildew. REI: 12-hour. PHI: 1-day.

**Miravis Prime® (pydiflumetofen, fludioxonil) Pepper, Tomato** 9.2-11.4 fl. oz. per acre. Use high rate for gray mold, suppression only. REI: 12-hour. PHI: 0-day.

**Orondis Opti Premix® (oxathiapiprolin, chlorothalonil) Pepper, Tomato** 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day.

**Pageant Intrinsic® (boscalid, pyraclostrobin) Pepper, Tomato** 23 oz. per acre. Labeled for greenhouse-/high tunnel-grown tomatoes. Do not apply on seedlings meant for transplanting in the field. REI: 12-hour. PHI: 0-day.

**Priaxor® (fluxapyroxad, pyraclostrobin) Pepper, Tomato** 4-8 fl. oz. per acre. Suppression only for Botrytis gray mold and white mold. REI: 12-hour. PHI: 0-day.

**Scala SC® (pyrimethanil) Pepper, Tomato** 7 fl. oz. per acre. See label for precautions. REI: 12-hour. PHI: 1-day.

**Switch 62.5WG® (cyprodinil, fludioxonil) Pepper, Tomato** 11-14 oz. per acre. Do not apply to small-fruited varieties in the greenhouse. REI: 12-hour. PHI: 0-day.

### **Late Blight of Tomatoes - Phytophthora Oomycete**

**chlorothalonil formulations (chlorothalonil) Pepper, Tomato** See label. Several chlorothalonil formulations (e.g., Bravo®, Echo®, and Equus®) are labeled for use at various rates. REI: 12-hour. PHI: 0-day.

**Gavel 75DF® (zoxamide, mancozeb) Tomato** 1.5-2 lbs. per acre. REI: 48-hour. PHI: 5-day.

**Orondis Opti Premix® (oxathiapiprolin, chlorothalonil) Pepper, Tomato** 1.75-2.5 pt. per acre. REI: 12-hour. PHI: 3-day.

**Orondis Ultra Premix® (oxathiapiprolin, mandipropamid) Tomato** 5.5-8 fl. oz. per acre. Alternate with fungicides that have a different mode of action. REI: 4-hour. PHI: 1-day.

**Presidio® (fluopicolide) Tomato** 3-4 fl. oz. per acre. Must be tank-mixed with a product with a different mode of action. REI: 12-hour. PHI: 2-day.

**Priaxor® (fluxapyroxad, pyraclostrobin) Tomato** 8 fl. oz. per acre. Suppression only for late blight. REI: 12-hour. PHI: 0-day.

**Ranman 400SC® (cyazofamid) Tomato** 2.75 fl. oz. per acre. For Buckeye rot and Phytophthora blight, apply to base of plant or in transplant water. See label for details. REI: 12-hour. PHI: 0-day.

**Revus Top® (mandipropamid, difenoconazole) Pepper, Tomato** 5.5-7 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day.

**Zampro® (ametoctradin, dimethomorph) Tomato** 14 fl. oz. per acre. REI: 12-hour. PHI: 4-day.

### **Leaf Blight of Tomatoes - Septoria Fungus**

This disease initially cause lesions on lower leaves of the tomato plant. Plant resistant varieties. Use wilt resistant "VF" cultivars, and avoid fields with a wilt history. Tomato plants weakened by wilt disease may be more prone to leaf blights. Practice 3-4-year rotation with unrelated crops. Rotate out of fields with a history of early blight or Septoria leaf spot.

**Group 11 Resistance:** Strains of the fungus that causes early blight that are resistant to group 11 fungicides have been observed in Indiana and Ohio. Group 11 products labeled for tomato and early blight include Cabrio® and Quadris®. Tank-mix group 11 fungicides with products that have a different mode of action, or alternate group 11 fungicides with fungicides that have a different group number. See Selected Information About Recommended Fungicides (page 79) for more information.

**Winter/Off-season:** Use crop rotations of at least 2-3 years.

**Planting:** Begin protective fungicide applications on a 7-14 day schedule.

**Aprovia Top® (difenoconazole, benzovindiflupyr (solatenol)) Eggplant, Pepper, Tomato** 10.5-13.5 fl. oz. per acre. Use of a spreader sticker is recommended. REI: 12-hour. PHI: 0-day.

**Cabrio EG® (pyraclostrobin) Pepper, Tomato** 8-12 oz. per acre. REI: 12-hour. PHI: 0-day.

**chlorothalonil formulations (chlorothalonil) Pepper, Tomato** See label. Several chlorothalonil formulations (e.g., Bravo®, Echo®, and Equus®) are labeled for use at various rates. REI: 12-hour. PHI: 0-day.

**Fontelis® (pentyliopyrad) Pepper, Tomato** 16-24 fl. oz. per acre. See label for greenhouse uses. REI: 12-hour. PHI: 0-day.

**Inspire Super® (difenoconazole, cyprodinil) Pepper, Tomato** 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day.

**Luna Sensation® (fluopyram, trifloxystrobin) Pepper, Tomato** 5-7.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**Luna Tranquility® (fluopyram, pyrimethanil) Pepper, Tomato** 11.2 fl. oz. per acre. Disease suppression of powdery mildew. REI: 12-hour. PHI: 1-day.

**mancozeb formulations (mancozeb) Pepper, Tomato** See label. Several mancozeb formulations (e.g., Dithane®, Manzate®, Penncozeb®, Roper®) are labeled for use at various rates. REI: 24-hour. PHI: 5-day.

**Miravis Prime® (pydiflumetofen, fludioxonil) Pepper, Tomato** 9.2-11.4 fl. oz. per acre. Use high rate for gray mold, suppression only. REI: 12-hour. PHI: 0-day.

**Priaxor® (fluxapyroxad, pyraclostrobin) Pepper, Tomato** 4-8 fl. oz. per acre. Suppression only for Botrytis gray mold and white mold. REI: 12-hour. PHI: 0-day.

**Quadris 2.08SC® (azoxystrobin) Pepper, Tomato** 5-6.2 fl. oz. per acre. REI: 4-hour. PHI: 0-day.

**Quadris Opti® (azoxystrobin, chlorothalonil) Pepper, Tomato** 1.3-1.6 pts. per acre. REI: 12-hour. PHI: 0-day.

**Revus Top® (mandipropamid, difenoconazole) Pepper, Tomato** 5.5-7 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day.

**Tanos® (famoxadone, cymoxanil) Pepper, Tomato** 8 oz. per acre. For late blight, tank-mix with a contact fungicide with a different mode of action. Disease suppression for bacterial diseases. REI: 12-hour. PHI: 3-day.

### **Leaf Mold of Tomatoes - *Passalora* Fungus**

This disease causes yellow lesions on the upper side of the tomato leaf. It is common in greenhouse and high tunnel tomatoes but is less common in open field tomatoes.

**Winter/Off-season:** Rotate crops at least 2-3 years and practice fall tillage. Use sanitation in greenhouse tomatoes.

**Greenhouse:** Scout for disease.

**Planting:** Control relative humidity in the greenhouse by venting and pruning. Labeled fungicides may help control leaf mold.

**Variety selection** Tomato Select crop varieties for competitiveness, disease resistance, and regional adaptability.

**Gavel 75DF® (zoxamide, mancozeb) Tomato** 1.5-2 lbs. per acre. REI: 48-hour. PHI: 5-day.

**Inspire Super® (difenoconazole, cyprodinil) Pepper, Tomato** 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day.

## Product/Disease Ratings for All Fruiting Vegetables<sup>1</sup>

Product (REI/PHI) <sup>2</sup>	Common Name MOA or FRAC code: fungicides with a number as the MOA code should be tank- mixed or alternated with a different MOA code according to the label.	Comments												
		Anthracnose (tomato)	Anthracnose (pepper)	Bacterial Canker	Bacterial Spot/Septic	Botrytis Gray Mold	Buckeye Rot	Early Blight	Septoria Leaf Blight	Late Blight (tomato)	Phytophthora Blight (pepper)	Leaf Mold	White Mold	
Actigard <sup>*</sup> (12/24)	acibenzolar-S-methyl (P)				F									Not for bell pepper. Do not apply to stressed plants.
Agri-Mycin 17 <sup>*</sup> , Ag Strep- tomycin <sup>*</sup>	streptomycin sulfate (25)				F									For use on tomato/pepper seedlings produced for transplanting only.
Aprovia Top <sup>*</sup> (12/20)	benzovindiflupyr (7), difenconazole (3)	VG	ID		ID		VG	VG			ID			Alternate with chlorothalonil for anthracnose.
Botran <sup>*</sup> (12/10)	2, 6-dichloro-4-nitroanaline (29)				G									Application to seedlings may result in injury.
Bravo <sup>*</sup> , Echo <sup>*</sup> , Equus <sup>*</sup> (12/0)	chlorothalonil (M)	G	G		F		F	G	VG		F			Effective against a wide range of fungal diseases. Not for greenhouse use.
Cabrio <sup>*</sup> (12/0)	pyraclostrobin (11)	G	VG		F		VG	VG	P			S		
Contans WG <sup>*</sup> (4/NA)	CON/M/91-08 (NA)											F		Pepper only.
copper (many trade names) (24/0)	copper (M)	F	F	P	F	P		F	F	F				Tank-mix with mancozeb products to overcome copper resistance in bacterial spot strains.
Curzate 60DF <sup>*</sup> (12/3)	cymoxanil (27)									VG				Translaminar systemic activity against tomato late blight.
Dithane <sup>*</sup> , Manzate <sup>*</sup> , Pennco- zeb <sup>*</sup> (24/5)	mancozeb (M)	F	G				G	G	F		F			Be sure product is labeled on pepper.
Elumin <sup>*</sup> (12/2)	ethaboxam (22)										G			Same FRAC group as Gavel <sup>*</sup>
Endura <sup>*</sup> (3/9)	boscalid (7)					VG		VG						Increase spray volumes as plants grow.
Fontelis <sup>*</sup> (12/0)	penthiopyrad (7)	S	S		G		VG	VG						
Gavel <sup>*</sup> (48/5)	mancozeb (M), zoaxamide (22)					F	G	G	F		F			May be used with copper products to manage bacterial spot.
Inspire Super <sup>*</sup> (12/0)	difenconazole (3), cyprodinil (9)	F	F			G	VG	G			G			
Luna Sensation <sup>*</sup> (12/3)	fluopyram (7), trifloxystrobin (11)	S	VG		G		ID	VG				G		Alternate with chlorothalonil for anthracnose.
Luna Tranquility <sup>*</sup> (12/1)	fluopyram (7), pyrimethanil (9)				ID		VG	VG						
Miravis Prime (12/0)	pydiflumeton (7), fludioxonil (12)		VG				ID	VG			ID			Alternate with chlorothalonil for anthracnose.
Orondis Opti <sup>*</sup> (4/3)	oxathiapiprolin (U15), chlorothalonil (M)								VG	VG				
Orondis Ridomil Gold SL <sup>*</sup> (48/28)	oxathiapiprolin (U15), mefenoxam (4)									VG				Apply to soil at planting.
Orondis Ultra <sup>*</sup> (4/1)	oxathiapiprolin (U15), mandipropamid (40)								VG	VG				
Presidio <sup>*</sup> (12/2)	fluopicolide (43)								VG	G				
Previcur Flex <sup>*</sup> (12/5)	propamocarb hydrochloride (28)								VG					
Priaxor <sup>*</sup> (12/0)	fluxapyroxad (7), pyraclostrobin (11)	G	G		F		VG	G	S			S		
Quadris <sup>*</sup> (4/0)	azoxystrobin (11)	G	VG			P	VG	VG	P					
Quadris Top <sup>*</sup> (12/0)	azoxystrobin (11), difenconazole (3)	G	VG				VG	VG			G			
Ranman <sup>*</sup> (12/0)	cyazofamid (21)								VG	G				
Reason <sup>*</sup> (12/14)	fenamidone (11)						VG	VG	S	S				
Revus Top <sup>*</sup> (12/1)	mandipropamid (40), difenconazole (3)	G					G	G	G		G			Not labeled on pepper.
Ridomil Gold GR <sup>*</sup> , Ridomil Gold SL <sup>*</sup> (48/7)	mefenoxam (4)					G			VG*	G*				*Effective against sensitive isolates only.
Scala <sup>*</sup> (12/1)	pyrimethanil (9)				G		G							Label includes greenhouse instructions.
Switch <sup>*</sup> (12/0)	cypredinil (9), fludioxanil (12)				G		VG							Do not apply to cherry or grape tomatoes in the greenhouse.
Tanos <sup>*</sup> (12/3)	cymoxanil (27), famoxadone (11)	F	G	S	S	S	G	G	G		G			Tank-mix with manzate or other EBDC.
Zampro <sup>*</sup> (12/4)	amitoctradin (45), dimethomorph (40)								VG	P				
Zing <sup>*</sup> (48/5)	zoxomide (22), chlorothalonil (M)						G	G	VG					

<sup>1</sup>Fungicide rating code: VG=very good. G=good. F=fair. P=poor. S=suppression only. ID=labeled, but insufficient data to allow rating. Based on research and experience of the authors.

<sup>2</sup>REI (re-entry interval) in hours: do not enter or allow workers to enter areas treated during the REI period. PHI (pre-harvest interval) in days: the minimum time that must pass between the last pesticide application and crop harvest..

**mancozeb formulations (mancozeb)** *Pepper, Tomato* See label. Several mancozeb formulations (e.g., Dithane®, Manzate®, Penncozeb®, Roper®) are labeled for use at various rates. REI: 24-hour. PHI: 5-day.

**Miravis Prime® (pydiflumetofen, fludioxonil)** *Pepper, Tomato* 9.2-11.4 fl. oz. per acre. Use high rate for gray mold, suppression only. REI: 12-hour. PHI: 0-day.

**Revus Top® (mandipropamid, difenoconazole)** *Pepper, Tomato* 5.5-7 fl. oz. per acre. Do not use on small-fruited varieties. REI: 12-hour. PHI: 1-day.

**Tanos® (famoxadone, cymoxanil)** *Pepper, Tomato* 8 oz. per acre. For late blight, tank-mix with a contact fungicide with a different mode of action. Disease suppression for bacterial diseases. REI: 12-hour. PHI: 3-day.

#### **Powdery Mildew of Tomatoes/Peppers - *Leveillula* Fungus**

**Aprovia Top® (difenoconazole, benzovindiflupyr (solatenol))** *Eggplant, Pepper, Tomato* 10.5-13.5 fl. oz. per acre. Use of a spreader sticker is recommended. REI: 12-hour. PHI: 0-day.

**Cabrio EG® (pyraclostrobin)** *Pepper, Tomato* 8-16 oz. per acre. REI: 12-hour. PHI: 0-day.

**Inspire Super® (difenoconazole, cyprodinil)** *Pepper, Tomato* 16-20 fl. oz. per acre. Do not apply to small fruited varieties such as cherry tomato. REI: 12-hour. PHI: 0-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** *Pepper, Tomato* 5-7.6 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**Luna Tranquility® (fluopyram, pyrimethanil)** *Pepper, Tomato* 11.2 fl. oz. per acre. Disease suppression of powdery mildew. REI: 12-hour. PHI: 1-day.

**Miravis Prime® (pydiflumetofen, fludioxonil)** *Pepper, Tomato* 9.2-11.4 fl. oz. per acre. Use high rate for gray mold, suppression only. REI: 12-hour. PHI: 0-day.

**Priaxor® (fluxapyroxad, pyraclostrobin)** *Tomato* 6-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Quadris 2.08SC® (azoxystrobin)** *Pepper, Tomato* 5-6.2 fl. oz. per acre. REI: 4-hour. PHI: 0-day.

**Quadris Opti® (azoxystrobin, chlorothalonil)** *Pepper, Tomato* 1.6 pts. per acre. REI: 12-hour. PHI: 0-day.

**Quadris Top® (azoxystrobin, difenoconazole)** *Pepper, Tomato* 8-14 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

#### **Root-Knot Nematode**

**Variety selection** *Tomato* Select crop varieties for competitiveness, disease resistance, and regional adaptability.

#### **Southern Blight of Tomatoes/Peppers/Eggplant - *Sclerotium* Fungus**

This disease is normally observed in southern climates or during seasons with above normal temperatures.

Crop rotations with small grains and deep plowing crop residue should help to reduce inoculum.

**Fontelis® (penthiopyrad)** *Pepper, Tomato* 1-1.6 fl. oz. per 1,000 row ft. Apply to base of plant as directed spray 5-10 days after transplanting and 14 days later. Follow up with effective fungicide as needed. REI: 12-hour. PHI: 0-day.

#### **Tomato Spotted Wilt Virus (TSWV)**

This virus is carried by thrips and can cause major loss to tomatoes if they infect young plants. Both viruses are more common in greenhouse and high tunnel situations. Since ornamental plants can be a source of thrips, avoid growing ornamental plants such as flowers from plugs with tomatoes either as transplants or with mature tomatoes. Controlling thrips may slow the spread of the virus in greenhouse and field. See also Impatiens necrotic spot virus.

**Variety selection** *Tomato* Select crop varieties for competitiveness, disease resistance, and regional adaptability.

#### **White Mold (Timber Rot) of Multiple Crops - *Sclerotinia* Fungus**

This disease may be more common in greenhouses and high tunnels than in open fields. The fungus that causes this disease is soilborne and often results in a woody appearance of the lower stem of the tomato plant. Avoid fields with history of the problem. Pathogen has a large host range.

**Winter/Off-season:** Use long rotations with corn or small grains. Growers should avoid rotations with tomato, pepper, potato, and snap bean.

**Greenhouse/Planting:** White mold may be common where tomato is grown yearly in the same soil such as under a greenhouse structure.

**Fruit Set:** Inspect plants for symptoms of white mold.

**Cabrio EG® (pyraclostrobin)** *Pepper, Tomato* 12-16 oz. per acre. Suppression only for Botrytis gray mold and white mold. REI: 12-hour. PHI: 0-day.

**Endura® (boscalid)** *Eggplant, Pepper, Tomato* 12.5 oz. per acre. REI: 12-hour. PHI: 0-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** *Pepper, Tomato* 7.6 fl. oz. per acre. Suppression only for anthracnose and white mold. REI: 12-hour. PHI: 3-day.

**Priaxor® (fluxapyroxad, pyraclostrobin)** *Pepper, Tomato* 4-8 fl. oz. per acre. Suppression only for Botrytis gray mold and white mold. REI: 12-hour. PHI: 0-day.

## Weed Control

### Recommended Controls

The fruiting vegetables are warm-season crops nearly always started as transplants. When growers transplant crops onto black or other opaque plastic mulch, they sometimes use herbicides underneath the mulch, depending on the weed pressure and labor available to pull weeds by hand. Weeds between beds are typically controlled with cultivation, hand hoeing, herbicides, or a combination of the three. Weeds along the edge of the plastic mulch can be a particular challenge for cultivation equipment, and shielded or directed herbicide applications can help with control there.

Fresh market crops are also grown without plastic mulch, and similar weed control measures are used. Organic mulches (such as straw) can also provide good weed control in and between rows if applied in a thick enough mat before weeds emerge.

### Burndown or Directed/Shielded Application

#### Broadleaf and Grass Weeds

**glyphosate formulations (glyphosate)** *Eggplant, Pepper, Tomato* Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qt. per acre or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal) at 0.66-3.3 qt. per acre. Broadcast 3 days before transplanting, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. Remove herbicide residue from plastic mulch prior to transplanting. Do not apply to row-middles of tomato or tomatillo. REI: 4-hour. PHI: 14-day.

**paraquat formulations (paraquat)** *Eggplant, Pepper, Tomato* 2-4 pt. per acre of 2.0 lb. per gal. formulations or 1.3-2.7 pt. per acre of 3 lb. per gal. formulations. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS

(0.25% v/v) per 25 gal. of solution and apply to weeds less than 6 inches tall. Apply prior to transplanting or after direct-seeding, but before crop emergence. The lowest rate can be applied directed between rows. Do not make more than 3 applications per year. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 24-hour. PHI: 30-day for tomato RUP.

### Burndown or Directed/Shielded Application

#### Broadleaf Weeds

**Aim EC® (carfentrazone)** *Eggplant, Pepper, Tomato* 0.5-2 fl. oz. per acre. Apply a minimum of 1 day prior to transplanting or 7 days prior to direct-seeding, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day.

### Preemergence Broadleaf and Grass Weeds

**Command 3ME® (clomazone)** *Pepper* 0.67-2.67 pt. per acre. Not for banana pepper. Use lower rate on coarse soils, and higher rate on fine soils. Apply before transplanting. Set plant roots below herbicide. May cause temporary bleaching of crop leaves. REI: 12-hour.

**Devrinol DF-XT® (napropamide)** *Eggplant, Pepper, Tomato* 2-4 lbs. per acre. Use lower rate on coarse sandy soils and higher rate on heavy clay soils and between rows. Apply and incorporate before transplanting. Applied prior to laying plastic mulch. After harvest or prior to planting succeeding crops, deep moldboard or disk plow. Do not seed alfalfa, small grains, sorghum, corn, or lettuce for 12 months after application. REI: 24-hour.

**Dual Magnum (s-metolachlor) at the following rates:**

**Note: Registered for use in eggplant and pepper grown in Illinois, Michigan, and Indiana only: applicators must have state 24c label. Illinois label expires March 25, 2024. Michigan label expires December 31, 2021. REI: 24-hour.**

*Eggplant* 0.5-1.33 pt. per acre. Apply before transplanting or within 48 hours after transplanting. Do not exceed 1 application and 1.33 pts. per acre per year. PHI: 60-day.

*Pepper* 0.5-1.0 pt. per acre. Apply before transplanting and do not incorporate, or apply within 48 hours after transplanting. Reduce risk

of crop injury by applying after transplanting and by using a directed spray rather than spraying over the top of transplants. Do not exceed 1 pt. per acre or 1 application per crop. PHI: 60-day.

**Tomato** 1-2 pt. per acre. Use lower rate on coarse soils. Apply prior to transplanting, or as a directed spray after transplanting. Apply as a directed spray to direct-seeded tomatoes at least 4 inches tall. When using a directed spray, minimize contact with the crop. Crop injury may occur under unfavorable growing conditions. See label for additional precautions. PHI: 30-day if rate does not exceed 1.33 pt. per acre per year, 90-day if rate exceeds 1.33 pt. per acre per year.

**Prowl H2O® (pendimethalin) Eggplant, Pepper, Tomato**

1 to 3 pt. per acre. For use under plastic, apply as a band to top of bed after bed formation and before laying plastic, and/or apply to row middles after transplanting. On bare ground, apply and incorporate before transplanting, or apply before transplanting without incorporation, or apply to established plants as a directed spray. Avoid root contact with Prowl-treated soil and avoid any contact with leaves or stems of crop. REI: 24-hour. PHI: 21-day for tomato, 70-day for pepper and eggplant.

**trifluralin formulations (trifluralin) at the following rates:**

**Pepper** Use 4EC formulations at 1-2 pt. per acre .10G formulations at 5-10 lb. per acre. Broadcast and incorporate before transplanting. May cause early stunting if growing conditions are unfavorable. To minimize injury, dip transplant roots in carbon slurry (2 lbs. per gal.) prior to planting, or include 2 oz. of carbon per gal. of transplant water. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour.

**Tomato** Use 4EC formulations at 1-2 pts. per acre. Use 10G formulations at 5-10 lbs. per acre. Direct-seeded: Apply as a directed spray between rows at thinning. Transplanted: Broadcast and incorporate before transplanting, or apply directed spray between rows after transplanting and incorporate. May cause early stunting if growing conditions are unfavorable. To minimize injury, dip transplant roots in carbon slurry (2 lbs. per gal.) prior to planting, or include 2 oz. of carbon per gal. of transplant water. Use low rate

on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour.

**Preemergence Broadleaf Weeds**

**League® (imazosulfuron) at the following rates:**

**Pepper** 4.0-6.4 oz. per acre. Apply between rows after peppers are well-established and at least 10 inches tall. Avoid contact with crop and with surface of plastic mulch if present. Or apply as a directed spray under the pepper canopy and contacting no more than the lower 2 inches of stem and avoiding contact with fruit. If small, emerged weeds are present include a manufacturer-approved surfactant. REI: 12-hour. PHI: 21-day.

**Tomato** 4.0-6.4 oz. per acre. *Transplanted, bare ground:* Apply to a prepared planting bed at least 1 day before transplanting. *Transplanted, plasticulture:* Apply to a prepared planting bed just prior to laying plastic mulch and at least 1 day before transplanting. *Over the top:* Apply to established direct-seed tomatoes from 4-5 leaf stage through early bloom stage or transplanted tomatoes from 3-5 days after transplanting through early bloom stage. *Directed spray:* Apply from crop row to row middle of established plants with at least 4-5 leaves. If small emerged weeds are present include a manufacturer-approved surfactant. REI: 12-hour. PHI: 21-day.

**Matrix SG® (rimsulfuron) Tomato** 1-4 oz. per acre. Can be applied at 2-4 oz. per acre for preemergence weed control. Apply at 1-2 oz. per acre for postemergence weed control to tomato plants of at least the cotyledon stage. Add 0.5 pt. of NIS per 25 gal. of spray solution (0.25% v/v) if emerged weeds are present. Apply when weeds are less than 1 inch tall. Soil activity requires rainfall within 5 days of application. If crop is stressed, chlorosis may occur. Do not exceed 4 oz. per acre per year. REI: 4-hour. PHI: 45-day.

**metribuzin formulations (metribuzin) Tomato** 4F formulations: 0.5-1 pt. per acre. 75DF formulations: 0.33-0.66 lb. per acre. Broadcast and incorporate before transplanting, or broadcast after transplants are established. Or, use 4F formulations at up to 2 pts. per acre, or 75DF formulations at 1.33 lbs. per acre and apply a directed spray between crop rows after transplants are established. May be applied preplant incorporated with trifluralin products for

improved weed control. Crop injury may occur if applied over the top of plants within 3 days of cool, wet, or cloudy weather. Wait at least 14 days between applications. Do not exceed 2 pts. of 4F formulations, or 1.33 lbs. of 75DF formulations per acre per season. REI: 12-hour. PHI: 7-day.

**Reflex® (fomesafen) Pepper and Tomato in Michigan only.** 1 pt. per acre. Applicators must have a 24c label. Michigan label expires December 31, 2023. Apply before transplanting. For use under plastic, apply after bed formation and before laying plastic. Use only once in two years on the same soil. See rotational crop restrictions. Use on transplanted tomato and pepper only. REI: 24-hour. PHI: 60-day for pepper, 70-day for tomato.

**Sandea® (halosulfuron) at the following rates:**

*Eggplant, Pepper 0.5-1.0 oz. per acre. Row middles only:* Apply to row middles avoiding contact with the crop and plastic mulch, if present. If weeds

are present, add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v). REI: 12-hour. PHI: 30-day.

*Tomato 0.5-1.0 oz. per acre. Direct-seeded:* Apply over the top once tomatoes have at least 4 true leaves through 30 days prior to harvest. To minimize risk of crop injury, apply as a directed/shielded spray. *Transplanted:* Apply to the soil surface after final soil preparation or bed shaping and just before applying plastic mulch. Wait at least 7 days after application before transplanting. Or apply a minimum of 14 days after transplanting over the top or as a directed/shielded spray. *Row middles on bare ground or plastic mulch:* Apply to row middles avoiding contact with the crop and plastic mulch, if present.

If weeds are present, add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v). Do not exceed 2 applications or 2 oz. per acre per 12 month period. REI: 12-hour. PHI: 30-day.

**Herbicides for All Fruiting Vegetables<sup>1</sup>**

Products (REI/PHI)	Common Name	Timing and Application Location Relative to Crop <sup>2</sup>			Incorporated	Timing Relative to Weeds	Weed Groups Controlled		Crops <sup>3</sup>			
		Before Transplanting	After Transplanting, between rows only	Postemergence			Preemergence	Postemergence	Annual Grasses	Small-seeded Broadleaves	Broadleaves	Tomato
Aim EC® (12h/-)	carfentrazone	X	X				X		X	X	X	X
Command 3ME® (12h/-)	clomazone	X				X		X	X	X		X
Dacthal W-75°, Dacthal Flowable® (12h/-)	DCPA			X		X		X			X	X
Devrinol 50DF® (12h)	napropamide	X			Yes	X		X	X		X	X
Dual Magnum® (24h/30-90d)	s-metolachlor	X	X			X		X	X		X	X
Gramoxone® (12h to 24h)	paraquat	X	X				X	X	X	X	X	X
Matrix® (4h/ 45d)	rimsulfuron	X		X		X	X	X	X	X	X	
Poast® (12h/20d)	sethoxydim			X			X	X			X	X
Prefar 4E® (12h/-)	bensulide	X			Yes	X		X				X
Prowl H2O® (12h/70d)	pendimethalin	X	X			X		X	X		X	X
Roundup®, others (12h/14d)	glyphosate	X	X				X	X	X	X	X	X
Sandea® (12h/30d)	halosulfuron	X	X	X		X	X		X	X	X	X
Select Max®, others (12h/20d)	clethodim			X			X	X			X	X
Spartan 4F® (12h/-)	sulfentrazone	X				X			X	X	X	
Treflan®, others (12h/-)	trifluralin	X	X		Yes	X		X	X		X	X
Tricor®. others (12h/7d)	metribuzin	X	X	X		X	X		X	X	X	X

<sup>1</sup>For effectiveness against specific weeds, see Relative Effectiveness of Herbicides for Vegetable Crops (page 68), and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbicides can cause serious crop injury and yield loss if not used properly.

<sup>2</sup>X=permitted for at least one crop.

<sup>3</sup>X=may be used for that crop.

**Spartan 4F® (sulfentrazone)** *Tomato* 2.25-8.0 fl. oz. per acre. Apply before transplanting as a broadcast or banded application. Will also control nutsedge. Do not use on soils classified as sand, which have less than 1% organic matter. Do not exceed 12 fl. oz. per year. REI: 12-hour.

### Preemergence Grass Weeds

**Dacthal Flowable® (DCPA)** *Eggplant, Tomato* Dacthal Flowable® at 6-14 pts. per acre. Apply 4-6 weeks after transplanting or when direct-seeded plants are 4-6 in. tall and when growing conditions favor good plant growth. May be applied over the top of transplants. REI: 12-hour.

**Dacthal W75® (DCPA)** *Eggplant, Pepper, Tomato* 6-14 lbs. per acre. Apply 4-6 weeks after transplanting when growing conditions favor good plant growth. May be applied over the top of transplants. REI: 12-hour.

**Prefar 4E® (bensulide)** *Eggplant, Pepper* 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting. REI: 12-hour.

### Postemergence Broadleaf Weeds

**League® (imazosulfuron)** See details in the Preemergence Broadleaf Weeds section of this chapter.

**Matrix SG® (rimsulfuron)** See details in the Preemergence Broadleaf Weeds section of this chapter.

**metribuzin formulations (metribuzin)** See details in the Preemergence Broadleaf Weeds section of this chapter.

**Sandea® (halosulfuron)** See details in the Preemergence Broadleaf Weeds section of this chapter.

### Postemergence Grass Weeds

**clethodim formulations (clethodim) at the following rates:**

*Eggplant, Pepper* Use 2 lb. per gal. formulations at 6-8 fl. oz. per acre with 1 qt. COC per 25 gal. of spray solution (1% v/v). Do not exceed 32 fl. oz. per acre per season. Use 0.97 lb. per gal. formulations at 9-16 fl. oz. per acre with 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. per acre per season. Use low rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 20-day.

**clethodim formulations (clethodim)** *Tomato* Use 2 lb. per gal. formulations at 6-16 fl. oz. per acre with 1 qt. COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. per acre per season. Use 0.97 lb. per gal. formulations at 9-32 fl. oz. per acre with 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. per acre per season. Use low rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 20-day.

**Poast (sethoxydim)** *Eggplant, Pepper, Tomato* 1.0-1.5 pt. per acre. Add 1 qt. COC per 25 gal. of spray solution (1% v/v). Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4.5 pt. per acre per season. REI: 12-hour. PHI: 20-day for eggplant and tomato, 7-day for peppers.

## Insect Control

### Recommended Controls

#### Aphids

Conserve natural enemies by avoiding broad-spectrum insecticide applications.

Limiting the use of some insecticides will conserve predators and parasites that help control aphid populations.

**Conserve or introduce natural enemies** *Eggplant, Pepper, Tomato* Numerous biological control agents are produced for deployment into greenhouse cropping systems. Biocontrols are the enemy of the enemy. Some can be purchased and deployed, and others can be conserved through non-crop habitat management and careful pesticide use.

**M-Pede® (potassium salts of fatty acids)** *Eggplant, Pepper, Tomato* 1-2% by volume. Must contact target insects to be effective. REI: 12-hour. PHI: 0-day. *OMRI-listed*.

**Actara® (thiamethoxam)** *Eggplant, Pepper, Tomato* 2-3 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Admire Pro® (imidacloprid)** *Eggplant, Pepper, Tomato* 1.3-2.2 fl. oz. per acre foliar application for eggplant, pepper, and tomato. 7.0-10.5 fl. oz. per acre soil application on eggplant and tomato, up to 14 fl. oz. per acre for pepper. Do not exceed 6.7 fl. oz. per acre

*OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.*

for foliar applications. Do not exceed 10.5 fl. oz. per acre for soil applications on eggplant and tomato, or 14 fl. oz. for pepper. REI: 12-hour. PHI: 0-day for foliar application, or 21-day for soil application.

**Assail 30SG® (acetamiprid)** *Eggplant, Pepper, Tomato* 2-4 oz. per acre. Do not exceed 16 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Beleaf 50SG® (flonicamid)** *Eggplant, Pepper, Tomato* 2.0-4.28 fl. oz. per acre. Do not exceed 8.4 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**dimethoate formulations (dimethoate)** *Pepper, Tomato* 0.5-0.6 pt. per acre for 4E and 400 formulations on pepper. 0.5-1.0 pt. per acre for 4E and 400 formulations on tomato. 0.75-1.5 pts. per acre for 2.67EC formulations on pepper and tomato. REI: see label. PHI: 0-day for pepper, 7-day for tomato.

**Fulfill® (pymetrozine)** *Eggplant, Pepper, Tomato* 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Lannate LV® (methomyl)** *Eggplant, Pepper, Tomato* 0.75-3.0 pts. per acre. Do not exceed 21 pts. per acre per season. REI: 48-hour. PHI: 1-day for tomato, 3-day for pepper, 5-day for eggplant. *RUP*.

**malathion formulations (malathion)** *Eggplant, Pepper, Tomato* 5EC formulations use 1.5-2.5 pts. per acre for eggplant, 1.0-2.5 pts. per acre for pepper, 1.5 pts. per acre for tomato. 57EC formulations use 1.0-1.5 pts. per acre on eggplant, 1.25-1.5 pts. per acre on pepper, 1.0-1.25 pts. per acre for tomato. 8E formulations use 1.0-1.56 pts. per acre for pepper, 1.5 pt. per acre for tomato. REI: 12-hour. PHI: 1-day for tomato, 3-day for eggplant and pepper.

**Movento® (spirotetramat)** *Eggplant, Pepper, Tomato* 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day.

**Orthene 97 Soluble® (acephate)** *Pepper* For Bell Pepper: Application rate is 0.5-1 lb. per acre. For all other peppers: Application rate is 0.5 lb. per acre. REI: 24-hour. PHI: 7-day.

**Platinum 75SG® (thiamethoxam)** *Eggplant, Pepper, Tomato* 1.66-3.67 oz. per acre. Soil application. Do not exceed 3.67 oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Sivanto Prime® (flupyradifurone)** *Eggplant, Pepper, Tomato* 7-12 fl. oz. per acre foliar application, or 21-28 fl. oz. per acre soil application. REI: 4-hour. PHI: 1-day for foliar application, or 45-day for soil application.

**Vydate L® (oxamyl)** *Eggplant, Pepper, Tomato* 2-4 pts. per acre. Do not exceed 12 pts. per acre per season for pepper. Do not exceed 16 pts. per acre per season for eggplant. Do not exceed 32 pts. per acre per season for tomato. REI: 48-hour. PHI: 1-day for eggplant, 3-day for tomato, 7-day for pepper. *RUP*.

## Caterpillars

There are many caterpillar pests of fruiting vegetables, including corn earworm/tomato fruitworm, tomato hornworm, tomato pinworm, European corn borer, cutworms, loopers, and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

**Bacillus thuringiensis formulations for Lepidopterans**  
(*Bacillus thuringiensis aizawai* strain ABTS-1857, *Bacillus thuringiensis aizawai* strain GC-91, *Bacillus thuringiensis kurstaki* strain ABTS-351, *Bacillus thuringiensis kurstaki* strain EVB-113-19, *Bacillus thuringiensis kurstaki* strain SA-11)  
*Eggplant, Pepper, Tomato* Various Bt products are available for control of young caterpillars (Agree®, Biobit®, Dipel®, Javelin®, etc.) Different Bt subspecies have different control properties. Check labels for rates, timing of application and required safety equipment. REI: 4-hour. PHI: 0-day.

**Ambush® (permethrin)** *Eggplant, Pepper, Tomato* Check label for specific caterpillars. 6.4-12.8 fl. oz. per acre for eggplant and pepper. 3.2-12.8 fl. oz. per acre for tomato. Do not exceed 38.4 fl. oz. per acre for eggplant or tomato. Do not exceed 51.2 fl. oz. per acre per season for pepper. REI: 12-hour. PHI: 0-day for tomato, 3 day for eggplant and pepper. *RUP*.

**Asana XL® (esfenvalerate)** *Eggplant, Pepper, Tomato* 2.9-9.6 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 67.8 fl. oz. per acre per season for eggplant and pepper. Do not exceed 96.9 fl. oz. per acre per season for tomato. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. *RUP*.

**Avaunt 30WDG® (indoxacarb)** *Eggplant, Pepper, Tomato* 2.5-3.5 fl. oz. per acre. Can control European Corn Borer in bell pepper only. Use at higher rate for fruitworms and armyworms. Check label for specific caterpillars. Do not exceed 14 oz. per acre per season. REI: 12-hour. PHI: 3-day.

**Baythroid XL® (beta-cyfluthrin)** *Eggplant, Pepper, Tomato* 1.6-2.8 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day for tomato, 7-day for eggplant and pepper. *RUP*.

**Brigade 2EC® (bifenthrin)** *Eggplant, Pepper, Tomato* 2.1-6.4 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 12.8 fl. oz. per acre per season for eggplant and pepper. Do not exceed 25.6 fl. oz. per acre per season for tomato. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. *RUP*.

**Coragen® (chlorantraniliprole)** *Eggplant, Pepper, Tomato* 1.0-7.5 fl. oz. per acre. Check label for specific caterpillars. Can be applied as either a foliar application or via drip chemigation. Chemigation will provide up to 30 days of control. Do not exceed 15.4 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Danitol 2.4EC® (fenpropathrin)** *Eggplant, Pepper, Tomato* 10.67 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 42.67 fl. oz. per acre per season. REI: 24-hour. PHI: 3-day. *RUP*.

**Diazinon AG500® (diazinon)** *Tomato* 2-4 qts. per acre. Check label for specific caterpillars. Apply to soil and incorporate before planting. Do not exceed 4 qts. per acre per season. REI: 2-day. *RUP*.

**Entrust SC® (spinosad)** *Eggplant, Pepper, Tomato* 3-8 fl. oz. per acre. Check label for specific caterpillars. Observe resistance management restrictions. Do not exceed 29 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day. *OMRI-listed*.

**Exirel® (cyantraniliprole)** *Eggplant, Pepper, Tomato* 7.0-13.5 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Harvanta® (cyclaniliprole)** *Eggplant, Pepper, Tomato* 10.9-16.4 fl. oz. per acre. Do not exceed 65.6 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Intrepid 2F® (methoxyfenozideqts.)** *Eggplant, Pepper, Tomato* 4-16 oz. per acre. Check label for specific caterpillars. Do not exceed 64 oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Lannate LV® (methomyl)** *Eggplant, Pepper, Tomato* 1.5-3.0 pts. per acre. Check label for specific caterpillars. Do not exceed 15 pts. per acre for eggplant. Do not exceed 12 pts. per acre for pepper. Do not exceed 21

pts. per acre per season for tomato. REI: 48-hour. PHI: 1-day for tomato, 3-day for pepper, 5-day for eggplant. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** *Eggplant, Pepper, Tomato* 2.24-4.0 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 24 fl. oz. per acre per season. Allow at least 7 days between applications. REI: 12-hour. PHI: 1-day. *RUP*.

**Orthene 97® Soluble (acephate)** *Pepper* 0.75-1.0 lb. per acre. Check label for specific caterpillars. For bell pepper only. REI: 24-hour. PHI: 7-day.

**Permethrin 3.2EC® (permethrin)** *Eggplant, Pepper, Tomato* 4-8 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 80 fl. oz. per acre per season for eggplant. Do not exceed 64 fl. oz. per acre per season for pepper. Do not exceed 48 fl. oz. per acre per season for tomato. REI: 12-hour. PHI: 0-day for tomato, 3-day for eggplant and pepper. *RUP*.

**Radiant 1SC® (spinetoram)** *Eggplant, Pepper, Tomato* 5-10 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Rimon 0.83EC® (novaluron)** *Eggplant, Pepper, Tomato* 9-12 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 36 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Sevin XLR Plus® (carbaryl)** *Eggplant, Pepper, Tomato* 1-2 qts. per acre. Check label for specific caterpillars. Do not exceed 8 qts. per acre per season. REI: 12-hour. PHI: 3-day.

**Verimark® (cyantraniliprole)** *Eggplant, Pepper, Tomato* 5-10 fl. oz. per acre. For drip chemigation or soil injection. Check label for specific caterpillars. Do not exceed 30.54 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Warrior II® (lambda-cyhalothrin)** *Eggplant, Pepper, Tomato* 0.96-1.92 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 23 fl. oz. per acre per season. REI: 24-hour. PHI: 5-day. *RUP*.

### **Colorado Potato Beetle**

**Trident® (Bacillus thuringiensis tenebrionis strain**

**SA-10)** *Eggplant, Pepper, Tomato* 3-6 qts. per acre. For control of young larvae. REI: 4-hour. PHI: 0-day. *OMRI-listed*.

*OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.*

**abamectin formulations (abamectin)** *Eggplant, Pepper, Tomato* 1.75-3.5 fl. oz. per acre for SC formulations. 8-16 fl. oz. per acre for 0.15SC formulations. Do not exceed 10.25 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Actara® (thiamethoxam)** *Eggplant, Pepper, Tomato* 2-3 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Admire Pro® (imidacloprid)** *Eggplant, Pepper, Tomato* 1.3-2.2 fl. oz. per acre foliar application for eggplant, pepper, and tomato. 7.0-10.5 fl. oz. per acre soil application on eggplant and tomato, up to 14 fl. oz. per acre for pepper. Do not exceed 6.7 fl. oz. per acre for foliar applications. Do not exceed 10.5 fl. oz. per acre for soil applications on eggplant and tomato, or 14 fl. oz. for pepper. REI: 12-hour. PHI: 0-day for foliar application, or 21-day for soil application.

**Ambush® (permethrin)** *Eggplant, Tomato* 9.6 fl. oz. per acre for eggplant. 3.2-12.8 fl. oz. per acre for tomato. Do not exceed 38.4 fl. oz. per acre. REI: 12-hour. PHI: 0-day for tomato, 3-day for eggplant. *RUP*.

**Asana XL® (esfenvalerate)** *Eggplant, Tomato* 5.8-9.6 fl. oz. per acre. Do not apply more than 67.2 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant. *RUP*.

**Assail 30SG® (acetamiprid)** *Eggplant, Pepper, Tomato* 1.5-2.5 oz. per acre. Do not exceed 16 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Baythroid XL® (beta-cyfluthrin)** *Eggplant, Pepper, Tomato* 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day for tomato, 7-day for eggplant and pepper. *RUP*.

**Brigade 2EC® (bifenthrin)** *Eggplant, Pepper, Tomato* 2.1-6.4 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 12.8 fl. oz. per acre per season for eggplant and pepper. Do not exceed 25.6 fl. oz. per acre per season for tomato. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. *RUP*.

**Coragen® (chlorantraniliprole)** *Eggplant, Pepper, Tomato* 3.5-5 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

**Entrust SC® (spinosad)** *Eggplant, Pepper, Tomato* 3-6 fl. oz. per acre. Observe resistance management restrictions. REI: 4-hour. PHI: 1-day. *OMRI-listed*.

**Exirel® (cyantraniliprole)** *Eggplant, Pepper, Tomato* 7.0-13.5 fl. oz. per acre. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Harvanta® (cyclaniliprole)** *Eggplant, Pepper, Tomato* 10.9-16.4 fl. oz. per acre. Do not exceed 65.6 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** *Eggplant, Pepper, Tomato* 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow at least 7 days between applications. REI: 12-hour. PHI: 1-day. *RUP*.

**Permethrin® 3.2EC (permethrin)** *Eggplant, Tomato* 2-8 fl. oz. per acre. Do not exceed 80 fl. oz. per acre per season for eggplant. Do not exceed 48 fl. oz. per acre per season for tomato. REI: 12-hour. PHI: 0-day for tomato, 3-day for eggplant. *RUP*.

**Platinum 75SG® (thiamethoxam)** *Eggplant, Pepper, Tomato* 1.66-3.67 oz. per acre. Soil Application. Do not exceed 3.67 oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Radiant 1SC® (spinetoram)** *Eggplant, Pepper, Tomato* 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Rimon 0.83EC® (novaluron)** *Eggplant, Pepper, Tomato* 9-12 fl. oz. per acre. Do not exceed 36 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Sivanto Prime® (flupyradifurone)** *Eggplant, Pepper, Tomato* 10.5-14 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

**Venom 70SG® (dinotefuran)** *Eggplant, Pepper, Tomato* 1-4 oz. per acre. Foliar application. REI: 12-hour. PHI: 1-day.

**Verimark® (cyantraniliprole)** *Eggplant, Pepper, Tomato* 5-10 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

**Vydate L® (oxamyl)** *Eggplant, Tomato* 2-4 pts. per acre. Do not exceed 16 pts. per acre per season for eggplant. Do not exceed 32 pts. per acre per season for tomato. REI: 48-hour. PHI: 1-day for eggplant, 3-day for tomato. *RUP*.

**Warrior II® (lambda-cyhalothrin)** *Eggplant, Pepper, Tomato* 1.28-1.92 fl. oz. per acre. Do not exceed 23 fl. oz. per acre per season. Not for use against western flower thrips. REI: 24-hour. PHI: 5-day. *RUP*.

### **Flea Beetles**

**Actara® (thiamethoxam)** *Eggplant, Pepper, Tomato* 2-3 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Admire Pro® (imidacloprid)** *Eggplant, Pepper, Tomato* Soil Application. 7.0-10.5 fl. oz. per acre for eggplant and tomato. 7-14 fl. oz. per acre for pepper. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day.

**Ambush® (permethrin)** *Eggplant, Pepper* 6.4-12.8 fl. oz. per acre. REI: 12-hour. PHI: 3-day. *RUP*.

**Asana XL® (esfenvalerate)** *Eggplant, Pepper, Tomato* 5.8-9.6 fl. oz. per acre. Do not apply more than 67.2 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** *Eggplant, Pepper, Tomato* 2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day for tomato, 7-day for eggplant and pepper. *RUP*.

**Brigade 2EC® (bifenthrin)** *Eggplant, Pepper, Tomato* 2.1-6.4 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 12.8 fl. oz. per acre per season for eggplant and pepper. Do not exceed 25.6 fl. oz. per acre per season for tomato. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** *Eggplant, Pepper, Tomato* 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow at least 7 days between applications. REI: 12-hour. PHI: 1-day. *RUP*.

**Permethrin 3.2EC® (permethrin)** *Eggplant* 4-8 fl. oz. per acre. Do not exceed 80 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. *RUP*.

**Permethrin 3.2EC® (permethrin)** *Pepper* 4-8 fl. oz. per acre. Bell Peppers only. Do not exceed 64 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. *RUP*.

**Platinum 75SG® (thiamethoxam)** *Eggplant, Pepper, Tomato* 1.66-3.67 oz. per acre. Soil Application. Do not exceed 3.67 oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Sevin XLR Plus® (carbaryl)** *Eggplant, Pepper, Tomato* 0.5-1 qt. per acre. Do not exceed 8 qt. per acre per crop. REI: 12-hour. PHI: 3-day.

**Venom 70SG® (dinotefuran)** *Eggplant, Pepper, Tomato* 1-4 fl. oz. per acre foliar application, or 5-7.5 fl. oz. per acre soil application. REI: 12-hour. PHI: 1-day for foliar application, or 21 day for soil application.

**Warrior II® (lambda-cyhalothrin)** *Eggplant, Pepper, Tomato* 1.28-1.92 fl. oz. per acre. Do not exceed 23 fl. oz. per acre per season. Not for use against western flower thrips. REI: 24-hour. PHI: 5-day. *RUP*.

## Fruit Flies

Starting 2 weeks before harvest, place bait fruits in fields in late afternoon, and examine next morning. If half of the baits show eggs, spray fields immediately at 4-6 day

intervals. Treat harvested fruit and hampers as soon as filled with a dust containing 0.1% stabilized pyrethrins plus 1.0% piperonyl butoxide (such as Evergreen Pro 60-6®), and move hampers to processing plant as soon as possible.

**Malathion 57EC® (malathion)** *Eggplant, Pepper, Tomato* 2.5 pts. per acre. REI: see label. PHI: 1-day.

## Mites

**Conserve or introduce natural enemies** *Eggplant, Pepper, Tomato* Numerous biological control agents are produced for deployment into greenhouse cropping systems. Biocontrols are the enemy of the enemy. Some can be purchased and deployed, and others can be conserved through non-crop habitat management and careful pesticide use.

**abamectin formulations (abamectin)** *Eggplant, Pepper, Tomato* 1.75-3.5 fl. oz. per acre for SC formulations. 8-16 fl. oz. per acre for 0.15SC formulations. Do not exceed 10.25 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Acramite 50WS® (bifenazate)** *Eggplant, Pepper, Tomato* 0.75-1 lb. per acre. Two-spotted spider mites only. Do not exceed 1 application per season. REI: 12-hour. PHI: 3-day.

**Kanemite 15SC® (acequinocyl)** *Eggplant, Pepper, Tomato* 31 fl. oz. per acre. Spider mites only. REI: 12-hour. PHI: 1-day.

**Movento® (spirotetramat)** *Eggplant, Pepper, Tomato* 4-5 fl. oz. per acre. Russet mites and broad mites only. Do not exceed 10 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day.

**Nealta® (cyflumetofen)** *Tomato* 13.7 fl. oz. per acre. Spider mites only. Do not exceed 27.4 fl. oz. per acre per crop. REI: 12-hour. PHI: 3-day.

**Oberon 2SC® (spiromesifen)** *Eggplant, Pepper, Tomato* 7-8.5 fl. oz. per acre. Do not exceed 25.5 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Portal® (fenpyroximate)** *Eggplant, Pepper, Tomato* 2 pt. per acre. Do not exceed 2 applications per season. REI: 12-hour. PHI: 1-day.

**Vydate L® (oxamyl)** *Eggplant* 2-4 pts. per acre. Do not exceed 16 pts. per acre per season. REI: 48-hour. PHI: 1-day. *RUP*.

**Wettable Sulfur (sulfur)** *Tomato* 5-30 lb. per acre.

Russet mites only. Sulfur as a dust is also effective. Thorough coverage is required. Do not apply when temperatures are above 95F or during a heavy dew. REI: 24-hour. PHI:

## Stink Bugs

**Actara® (thiamethoxam)** *Eggplant, Pepper, Tomato* 3.0-5.5 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Azera® (azadirachtin, pyrethrins)** *Eggplant, Pepper, Tomato* 1-3.5 pts. per acre. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Baythroid XL® (beta-cyfluthrin)** *Eggplant, Pepper, Tomato* 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day for tomato, 7-day for eggplant and pepper. RUP.

**Brigade 2EC® (bifenthrin)** *Eggplant, Pepper, Tomato* 2.1-6.4 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 12.8 fl. oz. per acre per season for eggplant and pepper. Do not exceed 25.6 fl. oz. per acre per season for tomato. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. RUP.

**Danitol 2.4EC® (fenpropathrin)** *Eggplant, Pepper, Tomato* 10.67 fl. oz. per acre. Do not exceed 42.67 fl. oz. per acre per season. REI: 24-hour. PHI: 3-day. RUP.

**Lannate LV® (methomyl)** *Pepper, Tomato* 1.5-3.0 pts. per acre. Brown Marmorated Stink Bugs only. Do not exceed 21 pts. per acre per season. REI: 48-hour. PHI: 1-day for tomato, 3-day for pepper. RUP.

**Mustang Maxx® (zeta-cypermethrin)** *Eggplant, Pepper, Tomato* 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 1-day. RUP.

**Venom 70SG® (dinotefuran)** *Eggplant, Pepper, Tomato* 1-4 oz. per acre. Foliar application. REI: 12-hour. PHI: 1-day.

**Warrior II® (lambda-cyhalothrin)** *Eggplant, Pepper, Tomato* 1.28-1.92 fl. oz. per acre. Do not exceed 23 fl. oz. per acre per season. Not for use against western flower thrips. REI: 24-hour. PHI: 5-day. RUP.

## Thrips

**Conserve or introduce natural enemies** *Eggplant, Pepper, Tomato* Numerous biological control agents are produced for deployment into greenhouse cropping systems. Biocontrols are the enemy of the enemy. Some can be purchased and deployed, and others can be conserved through non-crop habitat management and careful pesticide use.

**Aza-Direct® (azadirachtin)** *Eggplant, Pepper, Tomato* 1-3.5 pts. per acre. REI: 4-hour. PHI: 0-day. OMRI-listed.

**Grandevø® (Chromobacterium subtsugae strain PRAA4-1)** *Eggplant, Pepper, Tomato* 2-3 lb. per acre. REI: 4-hour. PHI: 0-day. OMRI-listed.

**Venerate® (Burkholderia spp. strain A396)** *Eggplant, Pepper, Tomato* 1-8 qts. per acre. REI: 4-hour. PHI: 0-day. OMRI-listed.

**abamectin formulations (abamectin)** *Eggplant, Pepper, Tomato* 1.75-3.5 fl. oz. per acre for SC formulations. 8-16 fl. oz. per acre for 0.15SC formulations. Do not exceed 10.25 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**Admire Pro® (imidacloprid)** *Eggplant, Pepper, Tomato* Soil Application. 7.0-10.5 fl. oz. per acre for eggplant and tomato. 7-14 fl. oz. per acre for pepper. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day.

**Assail 70WP® (acetamiprid)** *Eggplant, Pepper, Tomato* 0.075 lb. or 1.7 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Azera® (azadirachtin, pyrethrins)** *Eggplant, Pepper, Tomato* 2-3.5 pts. per acre. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Baythroid XL® (beta-cyfluthrin)** *Eggplant, Pepper, Tomato* 2.1-2.8 fl. oz. per acre. REI: 12-hour. PHI: 0-day. RUP.

**Brigade 2EC® (bifenthrin)** *Eggplant, Pepper, Tomato* 2.1-6.4 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 12.8 fl. oz. per acre per season for eggplant and pepper. Do not exceed 25.6 fl. oz. per acre per season for tomato. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. RUP.

**Closer SC® (sulfoxaflor)** *Eggplant, Pepper, Tomato* 4.25-4.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

**Entrust® (spinosad)** *Eggplant, Pepper, Tomato* 1.25-2.5 oz. per acre. REI: 4-hour. PHI: 1-day. OMRI-listed.

**Exirel® (cyantraniliprole)** *Eggplant, Pepper, Tomato* 13.5-20.5 fl. oz. per acre. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Harvanta® (cyclaniliprole)** *Eggplant, Pepper, Tomato* 10.9-16.4 fl. oz. per acre. Do not exceed 65.6 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Minecto Pro® (cyantraniliprole, abamectin)** *Eggplant, Pepper, Tomato* 10.0 fl. oz. per acre. REI: 12-hour. PHI: 1-day. RUP.

**Movento® (spirotetramat)** *Eggplant, Pepper, Tomato* 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** *Eggplant, Pepper, Tomato* 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between

applications. REI: 12-hour. PHI: 1-day. *RUP*.

**Platinum 2SC® (thiamethoxam)** *Eggplant, Pepper, Tomato* 5-11 fl. oz. per acre. REI: 12-hour. PHI: 30-day.

**Radiant 1SC® (spinetoram)** *Eggplant, Pepper, Tomato* 6-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Rimon 0.83EC® (novaluron)** *Eggplant, Pepper, Tomato* 12 oz. per acre. Do not exceed 36 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Torac 15EC® (tolfenpyrad)** *Eggplant, Pepper, Tomato* 21 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Venom 70SG® (dinotefuran)** *Eggplant, Pepper, Tomato* 1-4 fl. oz. per acre foliar application, or 5-7.5 fl. oz. per acre soil application REI: 12-hour. PHI: 1-day for foliar application, or 21 day for soil application.

**Warrior II® (lambda-cyhalothrin)** *Eggplant, Pepper, Tomato* 1.28-1.92 fl. oz. per acre. Do not exceed 23 fl. oz. per acre per season. Not for use against western flower thrips. REI: 24-hour. PHI: 5-day. *RUP*.

**Whiteflies**

**Conserve or introduce natural enemies** *Eggplant, Pepper, Tomato* Numerous biological control agents are produced for deployment into greenhouse cropping systems. Biocontrols are the enemy of the enemy. Some can be purchased and deployed, and others can be conserved through non-crop habitat management and careful pesticide use.

**Neemix® (azadirachtin)** *Eggplant, Pepper, Tomato* 4-16 fl. oz. per acre. For nymph (immature) control. REI: 4-hour. PHI: 0-day. *OMRI-listed*.

**Actara® (thiamethoxam)** *Eggplant, Pepper, Tomato* 3.0-5.5 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Admire Pro® (imidacloprid)** *Eggplant, Pepper, Tomato* 1.3-2.2 fl. oz. per acre foliar application for eggplant, pepper, and tomato. 7.0-10.5 fl. oz. per acre soil application on eggplant and tomato, up to 14 fl. oz. per acre for pepper. Do not exceed 6.7 fl. oz. per acre for foliar applications. Do not exceed 10.5 fl. oz. per acre for soil applications on eggplant and tomato, or 14 fl. oz. for pepper. REI: 12-hour. PHI: 0-day for foliar application, or 21-day for soil application.

**Asana XL® (esfenvalerate)** *Tomato* 5.8-9.6 fl. oz. per acre. Do not apply more than 67.2 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Assail 30SG® (acetamiprid)** *Eggplant, Pepper, Tomato* 2.5-4 oz. per acre. Do not exceed 16 oz. per acre per season REI: 12-hour. PHI: 7-day.

**Brigade 2EC® (bifenthrin)** *Eggplant, Pepper, Tomato* 2.1-6.4 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 12.8 fl. oz. per acre per season for eggplant and pepper. Do not exceed 25.6 fl. oz. per acre per season for tomato. REI: 12-hour. PHI: 1-day for tomato, 7-day for eggplant and pepper. *RUP*.

**Closer SC® (sulfoxaflor)** *Eggplant, Pepper, Tomato* 4.25-4.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

**Coragen® (chlorantraniliprole)** *Eggplant, Pepper, Tomato* 5.0-7.5 fl. oz. per acre. Can be applied as either a foliar application or via drip chemigation. Chemigation will provide up to 30 days of control. Do not exceed 15.4 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Exirel® (cyantraniliprole)** *Eggplant, Pepper, Tomato* 13.5-20.5 fl. oz. per acre. Do not exceed 61.7 fl. oz. per acre per season REI: 12-hour. PHI: 1-day.

**Knack® (pyriproxyfen)** *Eggplant, Pepper, Tomato* 8-10 fl. oz. per acre. Do not exceed 2 applications per season. REI: 12-hour. PHI: 1-day.

**Movento® (spirotetramat)** *Eggplant, Pepper, Tomato* 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day.

**Oberon 2SC® (spiromesifen)** *Eggplant, Pepper, Tomato* 7-8.5 fl. oz. per acre. Do not exceed 25.5 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Platinum 75SG® (thiamethoxam)** *Eggplant, Pepper, Tomato* 1.66-3.67 oz. per acre. Soil Application. Do not exceed 3.67 oz. per acre per season, or 1 application per season. REI: 12-hour. PHI: 30-day.

**Portal® (fenpyroximate)** *Eggplant, Pepper, Tomato* 2 pt. per acre. Do not exceed 2 applications per season. REI: 12-hour. PHI: 1-day.

**Sivanto Prime® (flupyradifurone)** *Eggplant, Pepper, Tomato* 10.5-14 fl. oz. per acre foliar application, or 21-28 fl. oz. per acre soil application. REI: 4-hour. PHI: 1-day for foliar application, or 45-day for soil application.

**Venom 70SG® (dinotefuran)** *Eggplant, Pepper, Tomato* 1-4 fl. oz. per acre foliar application, or 5-7.5 fl. oz. per acre soil application REI: 12-hour. PHI: 1-day for foliar application, or 21 day for soil application.

**Verimark® (cyantraniliprole)** *Eggplant, Pepper, Tomato* 6.75-13.5 fl. oz. per acre. Apply via drip chemigation or soil injection. REI: 4-hour. PHI: 1-day.

*OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.*

# Leafy Vegetables (Non-Brassica) and Herbs

## Basil, Chicory, Cilantro, Dill, Endive, Escarole, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard and More

Most herbs grow well under the same sunlight, fertility, soil and growing conditions, and cultural techniques similar to many vegetable crops. Pay special attention to drainage and moisture requirements of certain herbs, as many are very sensitive to soil moisture conditions.

Sage, rosemary, and thyme require well-drained, slightly moist soil, while parsley, chervil, and mint grow best on soils that retain moisture. Using plastic mulches, trickle irrigation, and raised beds may provide the necessary moisture and drainage requirements for the herb crop.

### Spacing

Raised beds are recommended for culinary herbs. These crops usually have common between-row spacing for convenience in cultivating. See individual herbs for details.

For leafy greens, these crops can have a common between-row spacing for convenience in cultivating.

**Lettuce and Endive:** Rows 12 to 15 inches apart. Plants 10 to 16 inches apart in row. Seed 1 to 2 pounds per acre.

**Spinach:** Rows 12 to 18 inches apart. Plants 4 to 6 per foot of row. Seed 12 to 20 pounds per acre.

**Parsley:** Rows 12 to 36 inches apart. Plants 4 to 12 inches apart in row. Seed 20 to 40 pounds per acre.

### Lime and Fertilizer

**Muck Soils:** Maintain soil pH between 5.5-6.0. Consider liming on muck soils when the pH falls below 5.5. Apply all fertilizer in a broadcast application and disk in prior to planting.

**Mineral Soils:** Maintain a soil pH of 6.0-7.0 for herbs, and 6.5 to 6.8 for leafy greens. Spinach is particularly sensitive to soil acidity. For average-fertility soils, apply 120 to 150 pounds of N per acre, 120 to 180 pounds of P<sub>2</sub>O<sub>5</sub> per acre, and 120 to 180 pounds of K<sub>2</sub>O per acre. Apply half before planting and the remainder as bands at planting, 2 inches to the side and 2 inches below the seed. Sidedress with 30 pounds of N per acre three to four weeks after thinning or transplanting.

**Preplant:** N: 60 pounds per acre. P<sub>2</sub>O<sub>5</sub>: 0 to 150 pounds per acre. K<sub>2</sub>O: 0 to 200 pounds per acre. Adjust according

to soil type, previous management, and soil test results for your state.

**Sidedress N:** For soils with more than 3 percent organic matter and following soybeans, alfalfa, or a grass-legume hay crop, apply 30 pounds N per acre. For soils with less than 3 percent organic matter and the above rotation, apply 45 pounds N per acre. Following corn, rye, oats, wheat, or a vegetable crop, apply 60 pounds N per acre. Use a total of 90 to 120 pounds N per acre for culinary herbs. For herbs grown for seeds, such as coriander, fennel, and dill, use 60 to 90 pounds N acre.

### Pest Control

Plastic or organic mulch is recommended for weed control. Most herbs are weak competitors to weeds, and while a few herbicides are registered on many herbs, they generally are for site preparation (glyphosate) or for preemergence control or postemergence control of emerged grasses. Weed control for the entire season requires integrating mulches, herbicides (if available), and cultivation. Practicing good sanitation and paying attention to seed sources will help to lessen diseases.

### Marketing Herbs

Fresh herbs certainly make excellent cash crops. However, growers should be cautious before beginning herb production. Establish markets and buyers need before purchasing any seed. Some of the most popular culinary herbs include basil, chives, dill, French tarragon, mints, oregano, parsley, rosemary, and thyme. However, growers should do their own marketing study to determine which herbs are suited for their areas. Possible outlets of culinary herbs include health food stores, grocery stores, upscale restaurants, farmers markets, and food manufacturing companies. Growers are also strongly encouraged to have greenhouses for year-round production. Detailed descriptions of some popular herbs follow.

#### Basil

Basil, French basil, or sweet basil (*Ocimum basilicum*) is a popular, tender, annual herb native to India and Asia.

Basil is commercially grown for its green, aromatic leaves, which are used fresh or dried as a flavoring. Fresh



Basil is a potentially high-value crop that may be grown successfully in a hydroponic setting.

basil leaves are used in tomato sauces and pesto sauces. Basil is also good with veal, lamb, fish, poultry, white beans, pasta, rice, tomatoes, cheese, and eggs. It is used in vinegar and tea.

Basil can be direct-seeded or transplanted to the field in late spring after all danger of frost is over. Basil seeds normally germinate in 8 to 14 days. Basil requires full sun and prefers moist, well-drained soil with a pH of 6.0. Typical spacing for basil is 12 inches between plants, 24 to 36 inches between rows. Suggested fertilizer should have an N-P-K ratio of 1-1-1 at a rate of 120-120-120 pounds per acre by a broadcast or plowdown. Sidedressing N at a rate of 15 to 30 pounds of actual N is recommended shortly after first harvest.

Trickle or overhead irrigation is necessary. Basil grown for dried leaves or essential oil is cut just prior to the appearance of flowers. The foliage should be cut at least four to six leaves above the ground to allow for regrowth and a subsequent crop. Information about insects and

disease of basil is limited. Japanese beetle, powdery mildew, and downy mildew have been reported to attack basil.

For weed control, a higher basil plant population coupled with mechanical cultivation is highly recommended. Refer to Sweet Basil: A Production Guide, Purdue Extension publication HO-189-W, available from the Education Store, [www.edustore.purdue.edu](http://www.edustore.purdue.edu).

### **Chives**

Chives, *Allium schoenoprasum*, is a perennial native to Asia. It was first used by the Chinese and then the ancient Greeks. Fresh leaves are excellent for making herbal vinegars and butter. It is also used in salad, soup, and cheese. Chives are also used to add a mild onion flavor to fish, salads, steamed vegetables, soups, and omelets.

Chive seeds require darkness, constant moisture, and a temperature of 60°F to 70°F for best results. Sow them 1/2 inch deep in pots or flats. Germination occurs in 2 to 3 weeks. Transplant seedlings to the field when they are 4 weeks old. Chives reach a height of 18 inches, a width of 1 to 2 inches the first year from seed, and 10 to 14 inches in subsequent years. Chives require full sun and well-drained soil with a pH of 6.0. No serious pests or diseases were reported, although chives can get downy mildew and rust. To harvest chives, cut chive leaves 2 inches above the ground.

### **Cilantro**

Cilantro, *Coriandrum sativum*, is an herb with a unique scent and flavor. Native to Egypt, cilantro is one of the most ancient herbs still cultivated. It is also known as Mexican parsley, Chinese parsley, or coriander. The dried seedpod is known as coriander and is usually used as a spice in baking and desserts. Cilantro leaves are a well-known salsa ingredient.

This annual plant does best in cool weather and should be planted in the early spring or in the fall. Optimum growing temperatures are between 50°F to 85°F. Plant seeds 1/2 inch deep and 2 to 3 inches apart. Germination may take 10-14 days. Cilantro grows 2 to 3 feet tall and thrives in moderately rich, light, well-drained soil in full to partial sun. Cilantro is highly salt sensitive, and soil electrical conductivity values exceeding 1 dS/m could reduce yields. Plants have shallow root systems, so frequent irrigation is needed. Cabbage looper and green peach aphid sometimes cause economic damage by curling and twisting leaves, and stunting the plant. Bacterial leaf spot, which is seedborne, and Fusarium wilt are common diseases in cilantro production. Effective management strategies involve using clean seed material and avoiding fields that have a history of Fusarium. To harvest, cut cilantro either just below the soil or 1.5 to 2 inches above the crown, bunched, and tied together with a rubber band. Popular cultivars include Long Standing, Santos, and Calypso.

## Dill

Dill, *Anthum graveolens*, is native to the Mediterranean area and southern Russia. It is a hardy annual and sometimes is grown as a biennial. Dill is commonly used as a seasoning for soups, fish, and pickles. Its aromatic leaves, seeds, flowers, and stems can also be used to flavor cabbage, vinegar, butter, apple pie, cakes, and bread.

Direct-seed in spring about 10 inches apart. Since dill has long taproots, it should not be transplanted. Fresh leaves should be harvested before flowering begins. Harvest seeds as soon as seed heads are brown and dry. Dill does not have any serious pest or disease problems. However, phoma blight, rusty root, and stem rot have been reported.

## Fennel

Fennel (*Foeniculum vulgare*) is a cool-season aromatic herb that originated in the Mediterranean region. It is a perennial but usually grown as an annual that grows to about 3 to 4 feet tall. Leaves are used as potherbs and for seasoning and garnishing purposes along with the bulb, which could be used as a fresh salad.

Planting can be done using seeds or transplants. Plant in full sun in rich and well-drained soil. Plant seeds at 1/4 to 1/2 inches deep in rows that are 2-3 feet apart. In-row spacing should be 10-12 inches. Transplant to the field early in the spring. Planting to harvesting for direct-seeded fennel could range from 90 to 150 days; and 110-125 days for transplanted fennel. Harvest by cutting just above the bulb near the leaf bases. Bulbs are further trimmed by cutting away most of the top growth. Leaf blight and stem rot are two major diseases affecting fennel.

## French Tarragon

French tarragon, *Artemisia dracunculus*, originates from southern Europe. Do not confuse it with Russian tarragon, *Artemisia dracunculoides*, which is much coarser, and has paler leaves, and a bitter taste. French tarragon is used to flavor vinegar, herbal butter, shellfish, pork, beef, poultry, many vegetables, and rice. Fresh leaves can also be used in salads, tartar sauce, and French dressing. French tarragon is a woody perennial that grows 2 feet tall.

It produces few seeds and must be propagated by stem cuttings or division. Plant in full sun in rich, well-drained soil with a pH of 6.9. Divide the plants every three to four years. Two harvests can generally be made each year, the first six to eight weeks after setting out. Harvest until leaves turn yellow in the fall. French tarragon is prone to root rot in heavy and wet soils.

## Mints

Mints, *Mentha spp.*, are a group of herbs that are mostly native to Europe and Asia. Some are indigenous to South America, America, and Australia. It is naturalized throughout North America from southern Canada and Mexico. With the possible exception of Corsian mint, mints are such rampant growers that they will quickly overwhelm other plants. Mints are commercially important as sources of flavor and menthol. Japanese mint (*M. Arvensis* var. *Piperescens*), peppermint (*M. Xpippita*), and spearmint (*M. Spicata*) are the mint species mostly cultivated.

Mints can be propagated by cuttings or seeds, except peppermint, since it is a sterile F1 hybrid of *M. Aquatica* and *M. Spicata*. Peppermint does not produce seeds and can only be propagated by cuttings. Mints can be planted in full sun or partial shade, and require rich, well-drained soil with a pH of 6.5. Mint can be harvested almost as soon as it comes up in the spring. Young, tender leaves and stems are the best. Mint is susceptible to verticillium wilt, mint rust, and mint anthracnose. Pests that could bother mint include spider mites, loopers, mint flea beetles, mint root borers, cutworms, root weevils, and aphids.

## Oregano

Oregano, *Origanum vulgare* subsp. *Hirtum* also referred to as *O. Heracleoticum* and *O. Hirtum*, is native to the Mediterranean region and naturalized in the eastern United States. It is added to tomato sauce for a hot and peppery taste. It adds dimension to yeast breads, marinated vegetables, roasted meats, and fish.

Oregano is a perennial and can be propagated by seeds. Direct-seed in the field and do not cover seeds; oregano seeds need sunlight to germinate. However, flavor can greatly vary among seed propagated plants. It is better to propagate by root divisions or cuttings from plants that are known to have strong flavor. Oregano reaches a height of 12 to 24 inches and a width of 10 to 20 inches. It requires a site with full sun and well-drained soil that has a pH of 6.8. Some of the pest and disease problems for oregano include aphids, leafminers, spider mites, and root rot. Oregano sprigs can be cut off when the plant is at least 6 inches high. In June, vigorously grown plants can be cut back to the lowest set of leaves. Plants generally leaf out after two weeks and can be cut back again in August.

## Parsley

Parsley is grown exclusively for its green leaves, or tops. The curled-leaf and Italian flat-leaf types are the most popular. Field-seeding begins in early April and ends

in May. Parsley is cut 1.5-2 inches from ground level to allow regrowth. About three or four cuttings are made, depending on the length of the growing season. Maintain soil pH at 5.5-6.0. Broadcast and disk in all fertilizer prior to planting. Apply 100 to 120 pounds of N per acre, 100 to 120 pounds of P<sub>2</sub>O<sub>5</sub> per acre, and 100 to 120 pounds of K<sub>2</sub>O per acre. After each cutting, broadcast 30 pounds of N per acre and cultivate. Row spacing should be 12 to 16 inches. Direct-seeding rate will depend on direct seeding equipment and could require 14 to 16 pounds per acre (70 percent germination). A 2-inch scattered shoe is used on most all planters. Row spacing depends on seeding equipment but is usually around 15 inches apart and in row plant spacing should be 4 to 8 inches. Seeding rate depends on seeding equipment and seed quality and could be up to 30 pounds per acre. Germination is enhanced by presoaking seeds in water for 24 hours and then allowing them to partially dry.

Popular curled-leaf parsley cultivars include Moss Curled, Dark Moss Curled, Banquet, Decorator, Deep Green, Forest Green, Improved Market Gardener, Sherwood, and Perfection. Plain-leaf type cultivars include Plain and Plain Italian Dark Green. Hamburg type, which is grown for its enlarged edible root consists of the Hamburg cultivar.

### Rosemary

Rosemary, *Rosmarinus officinalis*, is a tender perennial hardy to zones 8 to 10. It is native to the Mediterranean, Portugal, and northeastern Spain. It is pungent, somewhat piney, mint-like yet sweeter, with a slight ginger finale. Its flavor harmonizes with poultry, fish, lamb, beef, veal, pork, and game. Rosemary also enhances vegetables, cheese, and eggs.

Rosemary can be started from seeds, but germination rates are very low. Use fresh seeds, preferably less than two weeks old. Packaged seeds are difficult to germinate. Start plants from cuttings or by layering from existing plants. Rosemary grows slowly from seed, and eventually reaches a height of 72 inches and a width of 36 to 72 inches. Plant rosemary in a sunny location with well-drained and slightly acidic soil. Pest and disease problems include aphids, spider mites, scale, mealybugs, root rot, and *Botrytis* gray mold. Harvesting can be done throughout the year. Cut about 4-inch pieces from the tips of the branches, being careful not to remove more than 20 percent of the growth at one time.

### Thyme

Thyme, *Thymus vulgaris*, is native to the western Mediterranean region. It is a small, many-branched, and perennial shrub. Thyme tastes delicately green with a faint clover aftertaste. It ranks as one of the finest herbs of

French cuisine. Thyme leaves and sprigs are used in clam chowder, meats, herbal butter, and vinegar. Use it with vegetables, cheese, eggs, and rice.

Start seeds indoors and transplant seedlings into the field once the danger of frost is over. Thyme reaches a height of 12 inches and a width of 10 to 12 inches. Thyme can be propagated from cuttings, by layering, and division. The pest and disease problems include spider mites and root rot. Harvest the entire plant by cutting them back to 2 inches above ground in midsummer. One more harvest can be expected before the season ends.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### **Bottom Rot of Lettuce - Rhizoctonia Fungus**

Bottom rot is caused by Rhizoctonia. Avoid poorly drained fields with a history of the disease.

**azoxystrobin formulations (azoxystrobin) Head Lettuce, Leaf Lettuce** Trade names include Quadris® and Satori®. REI: 4-hour. PHI: 0-day.

**Endura® (boscalid) Head Lettuce, Leaf Lettuce** 8-11 oz. per acre. Bottom rot is suppression. REI: 12-hour. PHI: 14-day.

**iprodione formulations (iprodione) Head Lettuce, Leaf Lettuce** 1.5-2 pts. per acre. Formulations of iprodione including Nevado® and Rovral®. REI: 24-hour. PHI: 14-day.

**Luna Sensation® (fluopyram, trifloxystrobin) Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach** 7.6 fl. oz. per acre. Bottom rot suppression only. See label for restrictions. REI: 12-hour. PHI: 0-day.

#### **Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens**

Conditions that favor rapid germination limit damping-off severity. Avoid excessive irrigation and poorly drained soils. Good sanitation is critical to avoiding damping-off.

**Sanitation** Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce,

*Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* Clean and sanitize equipment, propagation trays/pots and greenhouse surfaces.

**Orondis Gold® (oxathiapiprolin, mefenoxam)** *Head Lettuce, Leaf Lettuce* REI: 4-hour.

**Previcur Flex® (propamocarb)** *Head Lettuce, Leaf Lettuce* For damping-off of lettuce caused by Pythium and Phytophthora only. REI: 12-hour.

### **Downy Mildew of Lettuce - *Bremia* Fungus**

**Variety selection** Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme Resistant or partially resistant varieties may be available for downy mildew or white rust.

**Actigard® (acibenzolar-s-methyl)** *Head Lettuce, Leaf Lettuce* 0.75-1 oz. per acre. REI: 12-hour. PHI: 7-day.

**azoxystrobin formulations (azoxystrobin)** *Head Lettuce, Leaf Lettuce* Brands include Quadris® and Satori®. REI: 4-hour. PHI: 0-day.

**Curzate 60DF® (cymoxanil)** *Head Lettuce, Leaf Lettuce, Spinach* 5.0 oz. per acre. REI: 12-hour. PHI: 1-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** *Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 7.6 fl. oz. per acre. Bottom rot suppression only. See label for restrictions. REI: 12-hour. PHI: 0-day.

**mancozeb formulations (mancozeb)** *Head Lettuce, Leaf Lettuce* REI: 24-hour. PHI: 10-day for head lettuce, 14-day for leaf lettuce.

**Merivon® (fluxapyroxad, pyraclostrobin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 6-11 fl. oz. per acre. Downy mildew suppression only. REI: 12-hour. PHI: 1-day.

**Orondis Ultra Premix® (oxathiapiprolin, mandipropamid)** *Head Lettuce, Leaf Lettuce, Spinach* 5.5-8.0 fl. oz. per acre. REI: 4-hour. PHI: 0-day.

**phosphite and phosphorous acid formulations (phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum)** *Basil, Borage,*

*Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* Check label carefully for presence of crop of interest, especially herbs. REI: see label.

**Presidio® (fluopicolide)** *Cress, Endive, Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 3-4 fl. oz. per acre. REI: 12-hour. PHI: 2-day.

**Previcur Flex® (propamocarb)** *Head Lettuce, Leaf Lettuce* 2 pts. per acre. REI: 12-hour. PHI: 2-day.

**Ranman 400SC® (cyazofamid)** *Basil* 2.75-3.0 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Ranman 400SC® (cyazofamid)** *Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 2.75 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Revus® (mandipropamid)** *Basil, Head Lettuce, Leaf Lettuce* 8 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

**Tanos® (famoxadone, cymoxanil)** *Chive, Endive, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 8-10 oz. per acre. REI: 12-hour. PHI: 1-day.

**Topguard EQ® (flutriafol, azoxystrobin)** *Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 6-8 fl. oz. per acre. REI: see label. PHI: 7-day.

**Zampro® (ametoctradin, dimethomorph)** *Endive, Fennel, Head Lettuce, Leaf Lettuce, Parsley* 14 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

### **Drop of Lettuce - *Sclerotinia* Fungus**

Lettuce drop is caused by *Sclerotinia*. Avoid poorly drained fields with a history of the disease.

**Contans WG® (Coniothyrium minitans)** *Head Lettuce, Leaf Lettuce* REI: 4-hour. OMRI-listed.

**Botran 75W® (dichloro-nitroaniline)** *Endive, Head Lettuce, Leaf Lettuce* Rate depends on crop and application method. Flowable formulations may be available. REI: see label.

**Endura® (boscalid)** *Head Lettuce, Leaf Lettuce* 8-11 oz. per acre. Bottom rot is suppression. REI: 12-hour. PHI: 14-day.

**Fontelis® (penthiopyrad)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 14-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**iprodione formulations (iprodione)** *Head Lettuce, Leaf Lettuce* 1.5-2 pts. per acre. Formulations of iprodione including Nevado® and Rovral®. REI: 24-hour. PHI: 14-day.

**Kenja 400SC® (isofetamid)** *Head Lettuce, Leaf Lettuce* 12.3 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** *Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 7.6 fl. oz. per acre. Bottom rot suppression only. See label for restrictions. REI: 12-hour. PHI: 0-day.

**Merivon® (fluxapyroxad, pyraclostrobin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 8-11 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

**Switch 62.5WG® (cyprodinil, fludioxonil)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 11-14 oz. per acre. REI: 12-hour. PHI: 0-day.

### **Gray Mold of Multiple Crops - Botrytis Fungus**

This disease often occurs in greenhouse production. Avoid condensation on foliage by providing adequate ventilation within the enclosure and avoiding overcrowding plants.

**Botran 75W® (dichloro-nitroaniline)** *Endive, Head Lettuce, Leaf Lettuce* Rate depends on crop and application method. Flowable formulations may be available. REI: see label.

**Endura® (boscalid)** *Head Lettuce, Leaf Lettuce* 8-11 oz. per acre. Bottom rot is suppression. REI: 12-hour. PHI: 14-day.

**Fontelis® (penthopyrad)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 14-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**Switch 62.5WG® (cyprodinil, fludioxonil)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach,*

*Swiss Chard, Tarragon, Thyme* 11-14 oz. per acre. REI: 12-hour. PHI: 0-day.

### **Powdery Mildew of Lettuce - Erysiphe Fungus**

Powdery mildew is more likely to be a problem in greenhouse lettuce than in open fields.

**Fontelis® (penthopyrad)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 14-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** *Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 7.6 fl. oz. per acre. Bottom rot suppression only. See label for restrictions. REI: 12-hour. PHI: 0-day.

**Merivon® (fluxapyroxad, pyraclostrobin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 4-11 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

**Procure 480SC® (triflumizole)** *Head Lettuce, Leaf Lettuce* 6-8 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Quintec® (quinoxyfen)** *Head Lettuce, Leaf Lettuce* 4-6 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

**Topguard EQ® (flutriafol, azoxystrobin)** *Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 6-8 fl. oz. per acre. REI: see label. PHI: 7-day.

### **White Rust of Spinach - Albugo Fungus**

**azoxystrobin formulations (azoxystrobin)** *Head Lettuce, Leaf Lettuce* Brands include Quadris, and Satori. REI: 4-hour. PHI: 0-day.

**Merivon® (fluxapyroxad, pyraclostrobin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 4-11 fl. oz. per acre. REI: 12-hour. PHI: 1-day.

### **phosphite and phosphorous acid formulations**

**(phosphorous acid, potassium phosphite, mono-dipotassium salts of phosphorous acid, mono- and dibasic sodium, potassium, and ammonium phosphites, fosetyl-aluminum)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head*

*Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* Check label carefully for presence of crop of interest, especially herbs. REI: see label.

**Presidio® (fluopicolide)** *Cress, Endive, Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 3-4 fl. oz. per acre. REI: 12-hour. PHI: 2-day.

**Ranman 400SC® (cyazofamid)** *Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 2.75 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Tanos® (famoxadone, cymoxanil)** *Chive, Endive, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 8-10 oz. per acre. REI: 12-hour. PHI: 1-day.

**Topguard EQ® (flutriafol, azoxystrobin)** *Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 6-8 fl. oz. per acre. REI: see label. PHI: 7-day.

### **Wilt of Multiple Crops - Fusarium Fungus**

**Variety selection** Basil Basil varieties with Fusarium wilt resistance are available.

## **Weed Control**

### **Leafy Vegetables (Non-Brassica) and Herbs**

Weed control in leafy vegetables often relies heavily on cultivation and hand weeding. These operations are most efficient when planting arrangement is designed with weed control in mind, and is designed to work with available weed control equipment. Specialized weeding equipment for leafy vegetables includes basket weeders, narrow-bladed hoes, and others. Using a stale seedbed is helpful to reduce weed pressure in the crop. For direct-seeded crops, a carefully timed weed-killing operation after the crop is seeded and just before emergence will buy a few weeks of time before cultivation or hand weeding is necessary. Just before the crop emerges, weeds could be killed with a flame weeder, or an approved nonselective herbicide. Using transplants is helpful for weed control because the size difference between weeds and crop early in the season make mechanical control easier. Plastic and paper mulches have been used with success for transplanted crops.

For specific weeds controlled by each herbicide, check Relative Effectiveness of Herbicides for Vegetable Crops (page 68).

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

We provide general recommendations for herbs and lettuce (general) and then specific crops (including herbs).

### **Weed Control for Herbs and Lettuce (General)**

Recommendations for specific crops are provided below.

#### **Preemergence Broadleaves and Grasses**

**Devrinol DF-XT® (napropamide)** *Basil, marjoram, rosemary, and savory* 2-4 lbs. per acre. Apply before or after seeding and incorporate into soil, or water-in with 0.2-0.4 inch of water. REI: 24-hour. 0-day PHI.

**Prefar 4E® (bensulide)** 5-6 qts. per acre. *Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio.* Mineral soils only. Apply and incorporate before seeding or apply after seeding and incorporate with irrigation. REI: 12-hour.

#### **Postemergence Broadleaves**

**Aim EC® (carfentrazone)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 1-2 fl. oz. per acre. For leafy vegetables (not including herbs): Apply as a burndown treatment at least 1 day before transplanting or at least 7 days before seeding. Tank-mix with another labeled burndown product for best control. For leafy vegetables and herbs: Apply to row middles with a hooded sprayer to control weeds up to 4 inches tall. Add COC, NIS, or MSO. AMS will improve weed control. Do not exceed 6.1 fl. oz. per acre per year. REI: 12-hour. 0-day PHI.

#### **Postemergence Grasses**

**clethodim formulations (clethodim)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Savory, Spinach, Swiss Chard, Tarragon, Thyme* Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Try on small area before spraying whole field. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per

Product (REI/PHI)	Common Name	Timing and Application		Location Relative to Crop <sup>2</sup>	Timing Relative to Weeds	Weed Groups Controlled	Crops <sup>3</sup>
		Before Seeding	After Seeding Before Emergence				
Aim EC® (12h)	carfentrazone	X	X	X	Yes	X	X X X X X X X X
Balan 60DF® (12h/-)	benefin	X	X	X		X X	X X X X X X X X
Caparol® (12h/30d to 40d)	prometryn	X	X	X		X X X X X X X X	X X X X X X X X
Dual Magnum® (24h/50d to 60d)	s-metolachlor	X				X X X X X X X X	X X X X X X X X
Fusilade DX 2E (12h/14d)	fluazifop		X			X X X X X X X X	X X X X X X X X
Gramoxone® (12h to 24h)	paraquat	X	X			X X X X X X X X	X X X X X X X X
Kerb 50WP® (24h/55d)	pronamide	X	X	X		X X X X X X X X	X X X X X X X X
Lorox 50DF® (24h/30d)	linuron	X		X		X X X X X X X X	X X X X X X X X
Roast® (12h/14d to 30d)	sethoxydim		X			X X X X X X X X	X X X X X X X X
Prefar 4E® (12h/-)	bensulide	X	X	X	Yes	X X X X X X X X	X X X X X X X X
Roundup®, others (12h/14d)	glyphosate	X	X	X		X X X X X X X X	X X X X X X X X
Scythe®	pelargonic acid	X	X	X		X X X X X X X X	X X X X X X X X
Select Max®, others (12h/14d to 32 d)	clethodim		X			X X X X X X X X	X X X X X X X X
Spin-Aid® (12h/40d)	phenmediphan		X			X X X X X X X X	X X X X X X X X
Stinger® (12h/21d)	clopyralid		X			X X X X X X X X	X X X X X X X X
Treflan®, others (12h/-)	trifluralin	X			Yes	X X X X X X X X	X X X X X X X X

<sup>1</sup>For effectiveness against specific weeds, see Relative Effectiveness of Herbicides for Vegetable Crops (page 68), and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbicides can cause serious crop injury and yield loss if not used properly.

<sup>2</sup>X=permitted for at least one crop.

<sup>3</sup>X=may be used for that crop. \*=processing crops only.

acre per season. REI: 24-hour. PHI: 14-day.

### **Postemergence Broadleaves and Grasses**

**Scythe® (pelargonic acid)** *Basil, Chive, Cress, Dill, Endive, Escarole, Fennel, Head Lettuce, Leaf Lettuce, Oregano, Parsley, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 5-10 gals. per acre. Apply as a burndown, or as a directed or hooded spray between rows in 75-200 gals. of water per acre. Use higher rate for large and mature weeds. For herbs (not including leafy greens): Apply prior to emergence of plants from seed or perennial rootstock, ensuring applications are made before crop emerges from the soil. REI: 12-hour.

**glyphosate formulations (glyphosate)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* See product label for rates, application volume, and adjuvants. Use 4L formulations at 1-3 qts. per acre. Apply to emerged annual and perennial weeds before planting. Transplants that contact freshly sprayed weeds can be seriously injured. Or apply between rows with a hooded or shielded sprayer. Crop will be injured if any spray contacts it. Use low rate for annuals and higher rates for perennials. REI: 4-hour. PHI: 14-day.

### **Weed Control for Basil**

**Aim EC® (carfentrazone)** *Postemergence broadleaves.* 1-2 fl. oz. per acre. Apply to area between rows with a hooded sprayer. Do not exceed 6 fl. oz. per acre per year. REI: 12-hour.0-day PHI.

**Devrinol DF-XT®** *Preemergence annual grasses and some small-seeded broadleaves.* 2-4 lbs. per acre. Apply before or after seeding and incorporate into soil, or water-in with 0.2-0.4 inch irrigation. 0-day PHI.

**glyphosate formulations (glyphosate)** *Postemergence annual and perennial weeds.* Use 4L formulations at 0.5-1 qt. per acre. Apply before planting.

**Scythe® (pelargonic acid)** *Postemergence grasses and broadleaves.* 5-10 gals. per acre. Apply as a directed or hooded spray between rows in 75-200 gals. of water per acre. Use higher rate for large weeds.

**clethodim formulations (clethodim)** *Postemergence grasses.* Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v)

Apply to actively growing grasses. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max per acre per year. REI: 24-hour. PHI: 14-day.

### **Weed Control for Cilantro**

**Caparol 4L® (prometryn)** *Preemergence.* 1-3.2 pts. per acre. *Do not use on sand or loamy sand soil.* Make 1 application after seeding before crop emerges. Higher rates may reduce crop stand. REI: 12-hour. 30-day PHI.

**Dual Magnum® (s-metolachlor)** *Preemergence annual grasses and broadleaves.* 0.67-1 pt. per acre. *Indiana, Michigan and Ohio only — applicators must have a 24c label.* Michigan and Ohio labels expire Dec 31, 2021. Apply to soil surface after seeding before crop emerges. Do not exceed 1 pt. per acre per year. REI: 24-hour. 30-day PHI.

**Lorox DF® (linuron)** 1-2 lbs. per acre.

*Preemergence:* Apply after seeding and before crop emergence. Use lower rate on sandy soil. Do not apply to soil with less than 1% organic matter.

*Postemergence:* Make up to 2 postemergence applications at 1-2 lbs. per acre after cilantro has 3 true leaves.

Do not spray when temperatures exceed 85F. Do not exceed 4 lbs. per acre per year. REI: See label. 21-day PHI.

**Poast® (sethoxydim)** *Postemergence grasses.* 1-1.5 pts. per acre. Apply to actively growing grasses. Include COC at 1 qt. per acre. Do not exceed 3 pts. per acre per year. REI: 12-hour. 15-day PHI.

**clethodim formulations (clethodim)** *Postemergence grasses.* Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v) Apply to actively growing grasses. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per year. REI: 24-hour. PHI: 14-day.

### **Weed Control for Dill**

**Caparol 4L® (prometryn)** 3.2 pts. per acre. *Michigan only,* applicators must have a 24c label. Michigan label expires Dec 31, 2019. Apply after seeding and before crop emergence or apply after crop emerges. Use a lower rate on sandy soil. Do not exceed one application or 3.2 pts. per acre per season. REI: 12-hour. PHI: 30-day.

**Lorox DF® (linuron)** 1-2 lbs. per acre.

**Preemergence:** Apply to damp soil after planting and before dill emerges. Do not apply to sandy soils or soils with less than 1% organic matter.

**Postemergence:** Apply to dill with at least 3 true leaves.

Do not exceed 4 lbs. per acre per year. Do not spray when temperature exceeds 85°F. Some varieties may be sensitive to Lorox®. REI: see label. PHI: 21-day.

**Poast (sethoxydim)** *Postemergence grasses.* 1-2.5 pts. per acre. Apply to actively growing grasses. Include COC at 1 qt. per acre. Do not exceed 5 pts. per acre per year. REI: 12-hour. PHI: 14-day

**clethodim formulations (clethodim)** *Postemergence grasses.* Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v) Apply to actively growing grasses. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per year. REI: 24-hour. PHI: 14-day.

## **Weed Control for Chicory, Endive, Escarole and Radicchio**

**Preemergence**

**Kerb SC® (pronamide)** *Preemergence grasses and small-seeded broadleaves.* 2.5-5 pts. per acre. Apply before or after seeding. Must be incorporated or irrigated into soil. Can be applied after crop emerges, but weed control will be marginal on muck soil. REI: 24-hour. PHI: 55-day. *RUP.*

**Prefar 4E® (bensulide)** *Preemergence grasses.* 5-6 qts. per acre. *Cress, Escarole, Endive, Florence Fennel, and Radicchio* Mineral soils only. Apply before planting and incorporate or apply after seeding (before crop emerges) and water in. REI: 12-hour.

**trifluralin formulations (trifluralin)** *Preemergence grasses and small-seeded broadleaves.* Use 4EC formulations at 1-2 pts. per acre. Use 10G formulations at 5-10 lbs. per acre. Apply and incorporate before seeding or transplanting. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour.

OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.

**Postemergence**

**Aim EC® (carfentrazone)** *Postemergence broadleaves* 2 fl. oz. per acre. Apply between rows with a hooded sprayer. Apply to weeds up to 3 inches. Add an adjuvant and nitrogen source. Do not exceed 2 applications per crop per year. REI: 12-hour. PHI: 0-day.

**Poast® (sethoxydim)** *Postemergence grasses.* 1-1.5 pts. per acre. Apply to actively growing grasses. Include 1 qt. COC per acre. Do not exceed 3 pts. per acre per season. 15-day PHI.

**glyphosate formulations (glyphosate)** *Postemergence perennials.* See product label for rates, application volume, and adjuvants. Use **4L formulations** at 2-3 qts. per acre. Apply before planting in the spring or after harvest in the fall. REI: 4-hour. PHI: 14-day.

**clethodim formulations (clethodim)** *Postemergence grasses.* Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v) Apply to actively growing grasses. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per year. REI: 24-hour. PHI: 14-day.

## **Weed Control for Lettuce (Leaf and Head)**

**Preemergence Annual Broadleaves and Grasses**

**Balan DF® (benefin)** 2-2.5 lbs. per acre. Apply and incorporate before seeding or transplanting. REI: 12-hour.

**Kerb SC® (pronamide)** 1.25-5 pts. per acre. Apply before or after seeding. Must be incorporated or irrigated into soil. Can be applied after crop emerges, but weed control will be marginal on muck soils. In Michigan only, use 4.8-7.2 qts. per acre on head lettuce on muck soils with greater than 20% organic matter; applicator must have 24c label (Michigan label expires April 6, 2022). REI: 24-hour. PHI: 25- to 55-day. *RUP.* **Prefar 4E (bensulide)** 5-6 qts. per acre. Apply preplant and incorporate or apply after seeding before lettuce emerges and water in. Mineral soils only. REI: 12-hour.

**Postemergence Broadleaves**

**Aim EC® (carfentrazone)** 2 fl. oz. per acre. Apply between rows with a hooded sprayer. Apply to weeds up to 3 inches tall. Add an adjuvant and nitrogen source. Do not exceed 2 applications per crop per year. REI: 12-hour. PHI: 0-day.

## Postemergence Grasses

**Fusilade DX® (fluazifop)** 10-12 fl. oz. per acre. Use 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gals. of spray solution. Apply to small actively growing grasses. Do not exceed 48 fl. oz. per acre per year. REI: 12-hour. 14-day PHI.

**Poast® (sethoxydim)** 1-1.5 pts. per acre. Apply to actively growing grasses. Include 1 qt. COC per acre. Do not exceed 3 pts. per acre per year. REI: 12-hour. PHI: 15-day for leaf lettuce, 30-day for head lettuce.

**clethodim formulations (clethodim)** Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Apply to actively growing grasses. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per year. REI: 24-hour. PHI: 14-day.

## Weed Control for Parsley

### Preemergence Annual Broadleaves and Grasses

**Caparol 4L®** at 1pts. per acre. Make 1 application up to 14 days after planting, a second application of 1 pt. per acre up to 30 days before harvest, and a third application up to 30 days before second harvest. Do not exceed 3 applications per year on all cuttings. To avoid crop injury, do not use on sand or loamy sand. REI: 12-hour. PHI: 30-day.

**Lorox DF® (linuron)** 1-3 lbs. per acre. Apply after seeding before crop emerges. Use low rate on coarse soils. REI: see label. PHI: 30-day.

**Prefar 4E® (bensulide)** Preemergence grasses. 5-6 qts. per acre. Mineral soils only. Apply preplant or preemergence. Incorporate or water in. REI: 12-hour.

### Postemergence Broadleaves

**Aim EC® (carfentrazone)** 1-2 fl. oz. per acre. Apply as a burndown treatment at least 7 days before seeding. Or apply to row middles with a hooded sprayer to control weeds up to 4 inches tall. Add COC, NIS, or MSO. Adding AMS will improve weed control. Do not exceed 6.1 fl. oz. per acre per year. REI: 12-hour. PHI: 0-day.

**Lorox DF® (linuron)** 1 lb. per acre. *Muck soils only.* Apply after parsley has 3 true leaves. Do not exceed 3 lbs. per acre per year combined pre and post. 30-day PHI.

## Postemergence Grasses

**Poast® (sethoxydim)** 1-1.5 pts. per acre. Apply to actively growing grasses. Include 1 qt. of COC per acre. Do not exceed 3 pts. per acre per year. REI: 12-hour. 15-day PHI.

### clethodim formulations (clethodim)

Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Apply to actively growing grasses. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per year. REI: 24-hour. PHI: 14-day.

## Postemergence Broadleaves and Grasses

**glyphosate formulations (glyphosate)** See product label for rates, application volume, and adjuvants. Use **4L formulations** at 2-3 qts. per acre. Apply to emerged perennials before planting in the spring or after harvest in the fall. REI: 4-hour. PHI: 14-day.

## Weed Control for Spinach

### Preemergence Broadleaves and Grasses

**Dual Magnum® (s-metolachlor)** 0.33-1.0 pt. per acre. *Illinois, Indiana, Ohio, and Michigan only.* Applicators must have a 24c label. Illinois label expires March 25, 2024. Michigan and Ohio labels expire Dec 31, 2021. Apply to soil surface after seeding before crop emerges. Do not incorporate. Use low rate on sandy soil. REI: 24-hour. PHI: 50-day.

**Ro-Neet® (cycloate)** 2 qts. per acre. *Illinois and Ohio only.* Apply before planting and immediately incorporate 2-3 inches. Use on sandy mineral soils only. REI: 48-hour. PHI: 45-day.

### Postemergence Broadleaves

**Spin-Aid® (phenmedipham)** 3-4 pts. per acre. *Spinach grown for processing or seed only, not for fresh market spinach.* Apply to spinach with 4-6 leaves when temperature is below 75°F. Do not spray when dew is present. Apply in 11-22 gals. per acre. May cause crop stunting. REI: 12-hour. 21-day PHI. *RUP.*

**Stinger® (clopyralid)** 2.7-5.3 fl. oz. per acre. Apply to spinach in the 2-5 leaf stage. Kills composite weeds, legumes, and nightshade. Do not exceed 2 applications and 8 fl. oz. per acre per year. REI: 12-hour. PHI: 21-day.

## Postemergence Grasses

**Poast® (sethoxydim)** 1-1.5 pts. per acre. Apply to actively growing grasses. Include 1 qt. of COC per acre. Do not exceed 3 pts. per acre per season. REI: 12-hour. PHI: 15-day.

**clethodim formulations (clethodim)** Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max® at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Apply to actively growing grasses. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per year. REI: 24-hour. PHI: 14-day.

## Weed Control for Swiss Chard

**Dual Magnum® (s-metolachlor)** Preemergence 0.5-1 pts. per acre. *Illinois, Indiana, and Michigan only* — applicators must have a 24c label. Illinois label expires March 25, 2024. Michigan label expires Dec 31, 2021. Apply after seeding before crop emerges. Use lower rate on sandy soil. Do not exceed 4 pts. per acre per year. 24-hour. PHI: 62-day.

**Poast® (sethoxydim)** Postemergence grasses. 1-1.5 pts. per acre. Apply to actively growing grasses. Include 1 qt. of COC per acre. Do not exceed 3 pts. per acre per year. REI: 12-hour. PHI: 30-day.

**clethodim formulations (clethodim)** Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Apply to actively growing grasses. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per year. REI: 24-hour. PHI: 14-day.

**Stinger (clopyralid)** 4-8 fl. oz. per acre. Postemergence broadleaves. *Michigan only: applicators must have a 24c label*. Make 1 broadcast application per season. Controls composite weeds, legumes, and nightshade. REI: 12-hour. PHI: 30-day

*OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.*

## Insect Control

### Recommended Controls

#### Aphids

*Seedlings:* 2 aphids per plant.

*Established Plants:* 7 aphids per plant.

**M-Pede® (potassium salts of fatty acids)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 1-2% by volume. Must contact aphids to be effective. Avoid spraying under hot conditions to minimize potential for plant injury. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Actara® (thiamethoxam)** *Chicory, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 1.5-3 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 4.4-10.5 fl. oz. per acre soil application, or 1.3 fl. oz. per acre foliar application on leafy greens. 4.4-10.5 fl. oz. per acre soil application for fennel and swiss chard. 7.0-10.5 fl. oz. per acre soil application, or 1.2 fl. oz. per acre foliar application on herbs. Do not exceed 10.5 fl. oz. per acre per season from soil applications. Do not exceed 3.6 fl. oz. per acre per season from foliar applications. REI: 12-hour. PHI: 45-day for soil application on fennel and swiss chard, 14-day for soil application on herbs, 21-day for soil application on leafy greens, 7-day for foliar applications on leafy greens and herbs

**Assail 30SG® (acetamiprid)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 2-4 oz. per acre. Do not exceed 20 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Belay® (clothianidin)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 9-12 fl. oz. per acre soil application, or 3-4 fl. oz. per acre foliar application. Do not exceed 12 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application.

**Beleaf 50SG® (flonicamid)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 2.0-2.8 oz. per acre. Do not exceed 8.4 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Brigade 2EC® (bifenthrin)** *Cilantro, Coriander* 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Brigade 2EC® (bifenthrin)** *Head Lettuce* 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**Capture LFR® (bifenthrin)** *Head Lettuce* 3.4-6.8 fl. oz. per acre. Lettuce root aphid only. See label for application methods. Do not exceed 0.1 lb. per acre per season as an at-plant application. Do not exceed 0.5 lb. per acre per season including at-plant plus foliar applications of other bifenthrin products (such as Brigade 2EC). REI: 12-hour. PHI: see label. RUP.

**dimethoate formulations (dimethoate)** *Endive, Leaf Lettuce, Swiss Chard* 0.5 pt. per acre for 4E and 400 formulations. 0.75 pt. per acre for 2.67EC formulations. Do not exceed 1 pt. per acre per season for 4E and 400 formulations. Do not exceed 2.2 pts. per acre per season for 2.67EC formulations. REI: see label. PHI: 14-day.

**Fulfill® (pymetrozine)** *Chicory, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Malathion 5EC® (malathion)** *Endive, Head Lettuce, Leaf Lettuce, Parsley, Spinach* 1.5-2.0 pts. per acre for endive. 1.5-2.4 pts. per acre for parsley. 1.6 pts. per acre for spinach. 2.5-3.0 pts. per acre for head and leaf lettuce. Do not exceed 2.4 pts. per acre per season for parsley. Do not exceed 2.0 pts. per acre per season for endive. Do not exceed 1.6 pts. per acre per season for spinach. Do not exceed 3 pts. per acre per season for head and leaf lettuce. REI: see label. PHI: 7-day for endive, parsley, and spinach; 14-day for head and leaf lettuce..

**Movento® (spirotetramat)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. REI: 24-hour. PHI: 3-day.

**Orthene 97 Soluble® (acephate)** *Head Lettuce* 8-16 oz. per acre. Do not exceed 2-1/8 lb. per acre per season. REI: 24-hour. PHI: 21-day.

**Platinum 2SC® (thiamethoxam)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 5-11 fl. oz. per acre. Soil application. Do not exceed 11 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Sivanto 200SL® (flupyradifurone)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 10.5-12 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Torac 15EC® (tolfenpyrad)** *Chicory, Cilantro, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 17-21 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per crop, or 2 applications per season. REI: 12-hour. PHI: 1-day.

## Caterpillars

There are many caterpillar pests of leafy vegetables and herbs, including cutworms, loopers, and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

Treat when 5% of plants are infested.

**Bacillus thuringiensis** formulations for Lepidopterans  
(*Bacillus thuringiensis aizawai* strain ABTS-1857, *Bacillus thuringiensis aizawai* strain GC-91, *Bacillus thuringiensis kurstaki* strain ABTS-351, *Bacillus thuringiensis kurstaki* strain EVB-113-19, *Bacillus thuringiensis kurstaki* strain SA-11) *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss*



These parsley transplants will have an advantage over plants that are direct seeded.

**Chard, Tarragon, Thyme** Various Bt products are available for control of young caterpillars (Agree, Biobit, Dipel, Javelin, etc.) Different Bt subspecies have different control properties. Check labels for pest insects controlled before use. Follow label directions for rates, timing of application and required safety equipment. REI: 4-hour. PHI: 0-day.

**Ambush® (permethrin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 6.4-12.8 oz. per acre. For loopers and armyworms. Do not exceed 8 lbs. per acre per season for leafy greens and herbs. Do not exceed 4 lbs. per acre per season for spinach. REI: 12-hour. PHI: 1-day. RUP.

**Avaunt 30WDG® (indoxacarb)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 2.5-6.0 oz. per acre. For loopers and armyworms. Do not exceed 24 oz. per acre per season for leafy greens and herbs. Do not exceed 14 oz. per acre for spinach. REI: 12-hour. PHI: 3-day.

**Baythroid XL® (beta-cyfluthrin)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Swiss Chard* 0.8-3.2 fl. oz. per acre. For cutworm, looper, and armyworm. Do not exceed 12.8 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day. RUP.

**Brigade 2EC® (bifenthrin)** *Cilantro, Coriander, Head Lettuce, Spinach* 2.1-6.4 fl. oz. per acre For cutworms, loopers and armyworms. Do not exceed 32 fl. oz. per acre per season for cilantro, coriander, or head lettuce. Do not exceed 25 fl. oz. per acre per season for spinach. REI: 12-hour. PHI: 3-day for cilantro and coriander; 7-day for head lettuce, 40-day for spinach. RUP.

**Confirm 2F® (tebufenozide)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* For cutworms, loopers and armyworms. Early season applications to young crop and small plants only: 6-8 fl. oz. per acre. Mid- to late-season applications (and to heavier infestations and under conditions in which thorough coverage is more difficult): 8 fl. oz. per acre. Do not apply more than 8 fl. oz. per application. Do not exceed 56 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day.

**Coragen® (chlorantraniliprole)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* For cutworms, loopers, and armyworms. 3.5-7.5 fl. oz. per acre for leafy greens as foliar or drip/chemigation application. 3.5-5.0 fl. oz. per acre for herbs as foliar application only. Do not exceed 15.4 fl. oz. per acre per crop, or 61.7 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Entrust SC® (spinosad)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 3-8 fl. oz. per acre for leafy greens. 4-6 fl. oz. per acre for herbs. Do not exceed 29 fl. oz. per acre per season for leafy greens. Do not exceed 30 fl. oz. per acre per season for herbs. Observe resistance management restrictions. REI: 4-hour. PHI: 1-day. OMRI-listed.

**Exirel® (cyantraniliprole)** *Chicory, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 10-17 fl. oz. per acre. For loopers and armyworms. Do not use adjuvants in tank mix in spinach. Do not exceed 61.7 fl. oz. per acre per season REI: 12-hour. PHI: 1-day.

**Intrepid 2F® (methoxyfenozide)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* For cutworm, looper, and armyworm. Early season applications: 4-8 fl. oz. per acre. Mid-to late-season applications: 8-10 fl. oz. per acre. Do not exceed 64 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Lannate LV® (methomyl)** *Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard* For cutworm, looper, and armyworm. 1.5-3.0 pts. per acre for parsley, spinach, and swiss chard. 0.75-3.0 pts. per acre for head and leaf lettuce. Do not exceed 12 pts. per acre for leaf lettuce, parsley, spinach, or swiss chard. Do not exceed 21 pts. per acre per season for head lettuce. REI: 48-hour. PHI: 7-day for spinach and lettuce under 1.5 pts. per acre, 10-day for parsley and swiss chard, 10-day for lettuce over 1.5 pts. per acre. RUP.

**Mustang Maxx® (zeta-cypermethrin)** *Chicory, Cilantro, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard*  
REI: 12-hour. RUP.

**Orthene 97 Soluble® (acephate)** *Head Lettuce* 1 lb. per acre. For loopers and armyworms. Do not exceed 2.2 lb. per acre per season. REI: 24-hour. PHI: 21-day.

**Pounce 25WP® (permethrin)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 3.2-12.8 oz. per acre. For cutworm, looper, and armyworm. Do not exceed 51.2 oz. per acre per season for leafy greens. Do not exceed 64.0 oz. per acre per season for Florence fennel and swiss chard. REI: 12-hour. PHI: 1-day. RUP.

**Radiant 1SC® (spinetoram)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 5-10 fl. oz. per acre. For cutworm, looper, and armyworm. Do not exceed 34 fl. oz. per acre per season for leafy greens. Do not exceed 39 fl. oz. per acre per season for herbs. REI: 4-hour. PHI: 1-day.

**Sevin XLR Plus® (carbaryl)** *Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard* 1-2 qts. per acre. For cutworm, looper, and armyworm. Do not exceed 6 qt. per acre per season. REI: 12-hour. PHI: 14-day.

### **Flea Beetles**

Seedlings: >50% plants infested and defoliation is >30%.

**Actara® (thiamethoxam)** *Chicory, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 1.5-3 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 4.4-10.5 fl. oz. per acre soil application, or 1.3 fl. oz. per acre foliar application on leafy greens. 4.4-10.5 fl. oz. per acre soil application for fennel and swiss chard. 7.0-10.5 fl. oz. per acre soil application, or 1.2 fl. oz. per acre foliar application on herbs. Do not exceed 10.5 fl. oz. per acre per season from soil applications. Do not exceed 3.6 fl. oz. per acre per season from foliar applications. REI: 12-hour. PHI: 45-day for soil application on

fennel and swiss chard, 14-day for soil application on herbs, 21-day for soil application on leafy greens, 7-day for foliar applications on leafy greens and herbs

**Ammo 2.5EC® (cypermethrin)** *Head Lettuce* 2.5-5.0 fl. oz. per acre. Do not exceed 30 fl. oz. per acre per season. REI: 12-hour. PHI: 5-day. RUP.

**Baythroid XL® (beta-cyfluthrin)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 2.4-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day. RUP.

**Belay® (clothianidin)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 9-12 fl. oz. per acre soil application, or 3-4 fl. oz. per acre foliar application. Do not exceed 12 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application.

**Brigade 2EC® (bifenthrin)** *Cilantro, Coriander* 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**Brigade 2EC® (bifenthrin)** *Head Lettuce* 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**Capture LFR® (bifenthrin)** *Cilantro, Coriander* 3.4-6.8 fl. oz. per acre. Soil application: See label for application methods. Do not exceed 0.1 lb. a.i. per acre per season as an at-plant application. Do not exceed 0.5 lb. a.i. per acre per season including at-plant plus foliar applications of other bifenthrin products (such as Brigade 2EC). REI: 12-hour. PHI: see label. RUP.

**Mustang Maxx® (zeta-cypermethrin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 5-day. RUP.

**Platinum 2SC® (thiamethoxam)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 5-11 fl. oz. per acre. Soil application. Do not exceed 11 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

*OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.*

**Pounce 25WP® (permethrin)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 3.2-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season for leafy greens. Do not exceed 64.0 oz. per acre per season for Florence fennel and swiss chard. REI: 12-hour. PHI: 1-day. RUP.

**Sevin XLR Plus® (carbaryl)** *Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard* 0.5-2 qts. per acre. Do not exceed 6 qt. per acre per season. REI: 12-hour. PHI: 14-day.

**Torac 15EC® (tolfenpyrad)** *Chicory, Cilantro, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 14-21 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per crop, or 2 applications per season. REI: 12-hour. PHI: 1-day.

**Warrior II® (lambda-cyhalothrin)** *Head Lettuce, Leaf Lettuce* 0.96-1.92 fl. oz. per acre. Do not exceed 19.2 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. RUP.

### **Leafhoppers**

**Neemix® (azadirachtin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 7-16 fl. oz. per acre. Nymphs only. REI: 4-hour. PHI: 0-day. OMRI-listed.

**Actara® (thiamethoxam)** *Chicory, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 1.5-3 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 4.4-10.5 fl. oz. per acre soil application, or 1.3 fl. oz. per acre foliar application on leafy greens. 4.4-10.5 fl. oz. per acre soil application for fennel and swiss chard. 7.0-10.5 fl. oz. per acre soil application, or 1.2 fl. oz. per acre foliar application on herbs. Do not exceed 10.5 fl. oz. per acre per season from soil applications. Do not exceed 3.6 fl. oz. per acre per season from foliar applications. REI: 12-hour. PHI: 45-day for soil application on fennel and swiss chard, 14-day for soil application

on herbs, 21-day for soil application on leafy greens, 7-day for foliar applications on leafy greens and herbs

**Ambush® (permethrin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 6.4-12.8 oz. per acre. Do not exceed 8 lbs. per acre per season for leafy greens and herbs. Do not exceed 4 lbs. per acre per season for spinach. REI: 12-hour. PHI: 1-day. RUP.

**Ammo 2.5EC® (cypermethrin)** *Head Lettuce* 2.5-5.0 fl. oz. per acre. Do not exceed 30 fl. oz. per acre per season. REI: 12-hour. PHI: 5-day. RUP.

**Baythroid XL® (beta-cyfluthrin)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 2.4-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day. RUP.

**Belay® (clothianidin)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 9-12 fl. oz. per acre soil application, or 3-4 fl. oz. per acre foliar application. Do not exceed 12 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application.

**Brigade 2EC® (bifenthrin)** *Head Lettuce* 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**dimethoate formulations (dimethoate)** *Endive, Leaf Lettuce, Swiss Chard* 0.5 pt. per acre for 4E and 400 formulations. 0.75 pt. per acre for 2.67EC formulations. Do not exceed 1 pt. per acre per season for 4E and 400 formulations. Do not exceed 2.2 pts. per acre per season for 2.67EC formulations. REI: see label. PHI: 14-day.

**Mustang Maxx® (zeta-cypermethrin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 5-day. RUP.

**Orthene 97 Soluble® (acephate)** Head Lettuce 8-16 oz. per acre. Do not exceed 2-1/8 lb. per acre per season. REI: 24-hour. PHI: 21-day.

**Platinum 2SC® (thiamethoxam)** Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard 5-11 fl. oz. per acre. Soil application. Do not exceed 11 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Pounce 25WP® (permethrin)** Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard 3.2-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season for leafy greens. Do not exceed 64.0 oz. per acre per season for Florence fennel and swiss chard. REI: 12-hour. PHI: 1-day. RUP.

**Sevin XLR Plus® (carbaryl)** Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard 0.5-2 qts. per acre. Do not exceed 6 qt. per acre per season. REI: 12-hour. PHI: 14-day.

**Sivanto 200SL® (flupyradifurone)** Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard 7-10.5 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Torac 15EC® (tolfenpyrad)** Chicory, Cilantro, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard 14-21 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per crop, or 2 applications per season. REI: 12-hour. PHI: 1-day.

**Venom 70SG® (dinotefuran)** Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard 1-3 fl. oz. per acre foliar application, or 5.0-7.5 fl. oz. per acre soil application. Do not exceed 6 fl. oz. per acre per season for foliar applications. Do not exceed 12 fl. oz. per acre per season for soil applications. REI: 12-hour. PHI: 7-day for foliar application, or 21-day for soil application.

**Warrior II® (lambda-cyhalothrin)** Head Lettuce, Leaf Lettuce 0.96-1.92 fl. oz. per acre. Do not exceed 19.2 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. RUP.

### **Leafminers**

**Seedlings:** 50% of plant infested.

**Near Harvest:** 5% of leaves infested.

**Neemix® (azadirachtin)** Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole,

Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme 4-7 fl. oz. per acre. Mix with oil-based adjuvant for best results. REI: 4-hour. PHI: 0-day. OMRI-listed.

**abamectin formulations (abamectin)** Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme 1.75-3.5 fl. oz. per acre. 1.75-3.5 fl. oz. per acre for SC formulations. 8-16 fl. oz. per acre for 0.15EC formulations. Use with NIS adjuvant. Do not use binder or sticker-type surfactants. Do not exceed 10.5 fl. oz. per acre for SC formulations. Do not exceed 48 fl. oz. per acre per season for 0.15EC formulations. REI: 12-hour. PHI: 7-day for leafy greens, 14-day for herbs. RUP.

**Ambush® (permethrin)** Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme 6.4-12.8 oz. per acre. Do not exceed 8 lbs. per acre per season for leafy greens and herbs. Do not exceed 4 lbs. per acre per season for spinach. REI: 12-hour. PHI: 1-day. RUP.

**Belay® (clothianidin)** Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard 9-12 fl. oz. per acre soil application, or 3-4 fl. oz. per acre foliar application. Do not exceed 12 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application.

**Brigade 2EC® (bifenthrin)** Cilantro, Coriander 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. RUP.

**dimethoate formulations (dimethoate)** Endive, Leaf Lettuce, Swiss Chard 0.5 pt. per acre for 4E and 400 formulations. 0.75 pt. per acre for 2.67EC formulations. Do not exceed 1 pt. per acre per season for 4E and 400 formulations. Do not exceed 2.2 pts. per acre per season for 2.67EC formulations. REI: see label. PHI: 14-day.

**Entrust SC® (spinosad)** Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard 6-10 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. Observe resistance management restrictions. REI: 4-hour. PHI: 1-day. OMRI-listed.

**Movento® (spirotetramat)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. REI: 24-hour. PHI: 3-day.

**Platinum 2SC® (thiamethoxam)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 5-11 fl. oz. per acre. Soil application. Do not exceed 11 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Pounce 25WP® (permethrin)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 3.2-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season for leafy greens. Do not exceed 64.0 oz. per acre per season for Florence fennel and swiss chard. REI: 12-hour. PHI: 1-day. *RUP*.

**Radiant 1SC® (spinetoram)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Trigard® (cyromazine)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 2.66 oz. per acre. Do not exceed 6 applications per season. REI: 12-hour. PHI: 7-day.

**Venom 70SG® (dinotefuran)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 1-3 fl. oz. per acre foliar application, or 5.0-7.5 fl. oz. per acre soil application. Do not exceed 6 fl. oz. per acre per season for foliar applications. Do not exceed 12 fl. oz. per acre per season for soil applications. REI: 12-hour. PHI: 7-day for foliar application, or 21-day for soil application.

## Mites

**abamectin formulations (abamectin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Cress, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 1.75-3.5 fl. oz. per acre. 1.75-3.5 fl. oz. per acre for SC formulations. 8-16 fl. oz. per acre for 0.15EC formulations. Use with NIS adjuvant. Do not use binder or sticker-type surfactants. Do not exceed 10.5 fl. oz. per acre for SC formulations. Do not exceed 48 fl. oz. per acre per season for 0.15EC formulations. REI: 12-hour. PHI: 7-day for leafy greens, 14-day for herbs. *RUP*.

**Brigade 2EC® (bifenthrin)** *Head Lettuce* 5.12-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Brigade 2EC® (bifenthrin)** *Spinach* 5.12-6.4 fl. oz. per acre. Do not exceed 25.6 fl. oz. per acre per season. REI: 12-hour. PHI: 40-day. *RUP*.

**Capture LFR® (bifenthrin)** *Head Lettuce* 3.4-6.8 fl. oz. per acre. Bulb mites only. See label for application methods. Do not exceed 0.1 lb. per acre per season as an at-plant application. Do not exceed 0.5 lb. per acre per season including at-plant plus foliar applications of other bifenthrin products (such as Brigade 2EC). REI: 12-hour. PHI: see label. *RUP*.

## Slugs

Prevent infestation by scattering bait products to the soil surface around the perimeter of the planting. Make a rescue treatment by scattering the bait products on the soil as a band between rows.

**Sluggo 1B® (iron phosphate)** *Head Lettuce, Leaf Lettuce, Spinach, Swiss Chard* 20-44 lb. per acre, or 0.5-1 lb. per 1,000 sq. ft. Scatter bait around the perimeter of plantings. REI: 0-hour. PHI: 0-day. OMRI-listed.

**Deadline M-Ps® (metaldehyde)** *Florence Fennel, Spinach, Swiss Chard* 25 lb. per acre. Scatter bait around the perimeter of plantings. Do not exceed 3 applications per crop cycle for spinach. Do not exceed 4 applications per crop cycle for Florence fennel and swiss chard. REI: 12. PHI: 0-day for spinach, 1-day for Florence fennel and swiss chard.

## Tarnished Plant Bug

Tarnished plant bug (TPB) damage to lettuce and spinach can reduce the marketability of these crops and can make them more susceptible to bacterial diseases. TPB adults and nymphs also feed on the youngest growth in the heart of the plant, which may lead to symptoms similar to blackheart.

No formal economic thresholds have been developed for this insect pest in leafy vegetables. However, in Canada, the thresholds used in celery have proven to be a suitable guideline for management decisions. Insecticide treatment is recommended whenever a threshold of 0.2 TPB per plant is reached from transplanting until three weeks before harvest. Note that in many cases, TPB damage is observed before large numbers of TPB nymphs and/or adults are detected.

**Baythroid XL® (beta-cyfluthrin)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 2.4-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 0-day. *RUP*.

**Beleaf 50SG® (flonicamid)** *Chicory, Cress, Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Radicchio, Spinach, Swiss Chard* 2.0-2.8 oz. per acre. Do not exceed 8.4 oz. per acre per season. REI: 12-hour. PHI: 0-day.

**Brigade 2EC® (bifenthrin)** *Head Lettuce* 5.12-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Brigade 2EC® (bifenthrin)** *Spinach* 5.12-6.4 fl. oz. per acre. Do not exceed 25.6 fl. oz. per acre per season. REI: 12-hour. PHI: 40-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** *Basil, Borage, Chicory, Chive, Cilantro, Coriander, Dill, Endive, Escarole, Fennel, Florence Fennel, Head Lettuce, Lavender, Leaf Lettuce, Marjoram, Oregano, Parsley, Radicchio, Rosemary, Sage, Savory, Spinach, Swiss Chard, Tarragon, Thyme* 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 5-day. *RUP*.

**Sevin XLR Plus® (carbaryl)** *Endive, Escarole, Florence Fennel, Head Lettuce, Leaf Lettuce, Parsley, Spinach, Swiss Chard* 0.5-2 qts. per acre. Do not exceed 6 qt. per acre per season. REI: 12-hour. PHI: 14-day.



Producing vegetables in high tunnels allows growers to extend the growing season and exploit new market windows.

# Legumes

## Legumes — Snap Bean, Dry Bean, Lima Bean

Snap beans refers to edible, podded beans that are usually green (green beans) or yellow (wax beans). They are harvested while pods and seeds are still tender. Older varieties (string beans) had a fibrous “string” the length of the pod that was removed during preparation for eating. Flat-podded Romano beans are also harvested while pods and seeds are tender.

Dry beans refers to a wide variety of beans harvested after the seeds are mature and pods have dried down. Kidney, navy, black turtle, white, and pinto beans are examples.

Lima beans represent a different species than snap beans and dry beans. They can be harvested when completely dry (like dry beans) or as “baby limas” before the seed has matured (similar to the southern pea described below).

## Legumes — Pea and Southern Pea or Cowpea

“Pea” has been commonly used to describe two distinctly different legume crops. English and Snow peas, both *Pisum sativum*, are cool-season crops grown for their immature edible seeds or pods. Snap peas are a type of English pea with tender, edible pods. Southern peas, or cowpeas, are *Vigna unguiculata* and include black-eyed peas, cream peas and crowder peas. These heat-loving crops are more commonly grown in southern states, although they can be grown in the north. They are grown for their immature shelled seeds and are well-accepted in markets where customers are familiar with them.

## Spacing

**Beans:** Rows 18 to 36 inches apart, 5 to 7 seeds per foot of row. Larger inter-row spacing helps limit white mold development. Seed 70 to 100 pounds per acre.

**Peas and Cowpeas:** Rows 32 to 36 inches apart, 6 to 8 seeds per foot of row. Seed 100 to 150 pounds per acre.

## Fertilizing

**Lime:** To maintain a soil pH of 6.0 to 6.8.

**Preplant:** N: for soils with more than 3 percent organic matter and following soybeans, alfalfa or a grass-legume

hay crop no N is needed. For soils with less than 3 percent organic matter and the above rotation apply 20 pounds N per acre for peas, and 30 pounds N per acre for beans. Following corn, rye, oats, wheat, or a vegetable crop apply 40 pounds N per acre for peas, and 40 to 60 pounds N per acre for beans.  $P_2O_5$ : 0 to 100 pounds per acre.  $K_2O$ : 0 to 100 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. Micronutrients: beans are prone to zinc deficiency. If the soil test shows zinc below 0.7 ppm, then prior to planting broadcast and incorporate 5 pounds of zinc per acre, or include 1 pound zinc per acre in the fertilizer band at planting.

**At Planting:** Apply 12 pounds N and 48 pounds  $P_2O_5$  per acre in bands at least 2 inches below and 2 inches to the side of the row. Potassium (K) is not recommended in the band because peas and beans are sensitive to injury from fertilizer salts.

**Sidedress N:** None needed.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### ***Anthracnose of Legumes - Colletotrichum Fungus***

Follow 2-3 year crop rotation. Rust resistant varieties are available. Use seed free of pathogens.

#### ***Crop rotation Beans (Dry), Southern Peas/Cowpeas***

Rotate between crop families to reduce disease inoculum buildup.

#### ***Aproach® (picoxystrobin) Beans (Dry), Peas (Dry)*** 6-12 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

#### ***Aprovia Top® (difenoconazole, benzovindiflupyr (solatenol)) Beans (Dry), Peas (Dry)*** 10.5-11 fl. oz. per acre. A spreader sticker is recommended. REI: 12-hour. PHI: 14-day.

**chlorothalonil formulations (chlorothalonil) Beans (Dry), Beans (Fresh), Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** Various chlorothalonil formulations (e.g., Bravo®, Echo®, Equus®, Initiate®) are labeled at various rates. REI: 12-hour. PHI: 7-day for fresh legumes, 14-day for dry legumes.

**Fontelis® (pentiopyrad) Beans (Dry), Peas (Dry)** 14-20 fl. oz. per acre. REI: 12-hour. PHI: 21-day PHI.

**Fontelis® (pentiopyrad) Beans (Fresh), Lima Beans, Peas (Fresh)** 14-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Headline SC® (pyraclostrobin) Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** 6-9 fl. oz. per acre. Some formulations may be listed as simply Headline without an SC designation. REI: 12-hour. PHI: 7-day for fresh. 21-days for dry.

**Priaxor® (fluxapyroxad, pyraclostrobin) Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day for fresh legumes, 21-day for dry legumes.

**Quadris 2.08SC® (azoxystrobin) Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** 6.0-15.4 fl. oz. per acre. REI: 4-hour. PHI: 0-day for fresh legumes, 14-day for dry legumes.

**Quadris Opti® (azoxystrobin, chlorothalonil) Beans (Dry)** 1.6-2.4 pts. per acre. REI: 12-hour. PHI: 14-day.

**Quilt® (azoxystrobin, propiconazole) Beans (Dry), Beans (Fresh), Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** 14 fl. oz. per acre. REI: 12-hour. PHI: 7-day for fresh legumes, 14-day for dry legumes.

**Quilt Xcel® (azoxystrobin, propiconazole) Beans (Dry), Beans (Fresh), Peas (Fresh), Southern Peas/Cowpeas** 10.5-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day for fresh legumes, 14-day for dry legumes.

**Tilt® (propiconazole) Beans (Dry), Beans (Fresh), Lima Beans, Southern Peas/Cowpeas** 4 fl. oz. per acre. REI: 12-hour. PHI: 7-day for fresh legumes.

**Topsin M WSB® (thiophanate-methyl) Beans (Dry), Beans (Fresh), Peas (Fresh), Southern Peas/Cowpeas** REI: see label. PHI: 14-day for fresh legumes, 28-day for dry legumes.

**Vertisan® (pentiopyrad) Beans (Dry), Southern Peas/Cowpeas** 14-20 fl. oz. per acre. REI: 12. PHI: 21-day.

## **Common Bacterial Blight of Beans - *Xanthomonas Bacteria***

**Crop rotation Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** Practice a 2-year crop rotation.

**Use healthy, disease-free seed Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** Plant western-grown, certified disease-free seed.

**Tillage Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** Plow under bean stubble in the fall.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** REI: see label. PHI: 0-day.

## **Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens**

**Use healthy, disease-free seed Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas**

**Ridomil Gold SL® (mefenoxam) Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** 0.5-1.0 pt. per acre. Apply at planting if Pythium is a significant problem. REI: 48-hour.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin) Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** Purchase seed commercially treated with a product such as Apron Maxx, Captan or Thiram.

## **Gray Mold of Multiple Crops - *Botrytis Fungus***

**Land selection Beans (Dry), Beans (Fresh), Southern Peas/Cowpeas** If possible, avoid fields with a history of disease problems.

**Cannonball WG® (fludioxonil) Beans (Dry), Beans (Fresh), Southern Peas/Cowpeas** 7 oz. per acre. Do not exceed 28 oz. per year. REI: 12-hour. PHI: 7-day.

**chlorothalonil formulations (chlorothalonil) Beans (Fresh)** REI: 12-hour. PHI: 7-day.

**Endura® (boscalid) Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas** 8-11 oz. per acre. REI: 12-hour. PHI: 7-day for fresh legumes, 21-day for dry legumes.

**Fontelis® (penthopyrad)** Beans (Dry), Peas (Dry) 14-20 fl. oz. per acre. REI: 12-hour. PHI: 21-day PHI.

**Fontelis® (penthopyrad)** Beans (Fresh), Lima Beans, Peas (Fresh) 14-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Omega 500F® (fluazinam)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.5-0.85 pts. per acre. Do not exceed 1.75 pts. per acre per season. REI: see label. PHI: 14-day for fresh legumes, 30-day for dry legumes.

**Rovral 4F® (iprodione)** Beans (Dry), Beans (Fresh), Lima Beans, Southern Peas/Cowpeas 1.5-2 pts. per acre. REI: 24-hour. PHI: 7-day.

**Switch 62.5WG® (cyprodinil, fludioxonil)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 11-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Topsin M WSB® (thiophanate-methyl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas REI: see label. PHI: 14-day for fresh, 28-day for dry legume.

### ***Halo Blight of Beans - Pseudomonas Bacteria***

**Crop rotation** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas Practice a 2-year crop rotation.

**Use healthy, disease-free seed** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas Plant western-grown, certified disease-free seed.

**Tillage** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas Plow under bean stubble in the fall.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas REI: see label. PHI: 0-day.

### ***Rust of Legumes - Uromyces Fungus***

Follow 2-3 year crop rotation. Rust resistant varieties are available. Use seed free of pathogens.

**Crop rotation** Beans (Dry), Southern Peas/Cowpeas Rotate between crop families to reduce disease inoculum buildup.

**Variety selection** Beans (Dry), Southern Peas/Cowpeas Use resistant cultivars.

**Aproach® (picoxystrobin)** Beans (Dry), Peas (Dry) 6-12 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Aprovia Top® (difenoconazole, benzovindiflupyr (soltatenol))** Beans (Dry), Peas (Dry) 10.5-11 fl. oz. per acre. A spreader sticker is recommended. REI: 12-hour. PHI: 14-day.

**chlorothalonil formulations (chlorothalonil)** Beans (Fresh) REI: 12-hour. PHI: 7-day.

**Fontelis® (penthopyrad)** Beans (Dry), Peas (Dry) 14-20 fl. oz. per acre. REI: 12-hour. PHI: 21-day PHI.

**Fontelis® (penthopyrad)** Beans (Fresh), Lima Beans, Peas (Fresh) 14-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Headline SC® (pyraclostrobin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 6-9 fl. oz. per acre. Some formulations may be listed as simply Headline without an SC designation. REI: 12-hour. PHI: 7-day for fresh. 21-days for dry.

**Priaxor® (fluxapyroxad, pyraclostrobin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day for fresh legumes, 21-day for dry legumes.

**Proline 480SC® (prothioconazole)** Beans (Dry), Southern Peas/Cowpeas 5.7 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Quadris 2.08SC® (azoxystrobin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 6 fl. oz. per acre. REI: 4-hour. PHI: 0-day for fresh legumes, 14-day for dry legumes.

**Quadris Opti® (azoxystrobin, chlorothalonil)** Beans (Dry) 1.6-2.4 pts. per acre. REI: 12-hour. PHI: 14-day.

**Quilt® (azoxystrobin, propiconazole)** Beans (Dry), Beans (Fresh), Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 14 fl. oz. per acre. REI: 12-hour. PHI: 7-day for fresh legumes, 14-day for dry legumes.

**Quilt Xcel® (azoxystrobin, propiconazole)** Beans (Dry), Beans (Fresh), Peas (Fresh), Southern Peas/Cowpeas 10.5-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day for fresh legumes, 14-day for dry legumes.

**Rally 40WSP® (myclobutanil)** Beans (Fresh) 4-5 fl. oz. per acre. Snap beans only. REI: 24-hour. PHI: 0-day.

**Tilt® (propiconazole)** Beans (Dry), Beans (Fresh), Lima Beans, Southern Peas/Cowpeas 4 fl. oz. per acre. REI: 12-hour. PHI: 7-day for fresh legumes.

**Vertisan (penthopyrad)** Beans (Dry), Southern Peas/Cowpeas 14-20 fl. oz. per acre. REI: 12. PHI: 21-day.

**Soybean Cyst Nematode (SCN)**

**Crop rotation** Beans (Dry), Beans (Fresh), Lima Beans, Southern Peas/Cowpeas Rotate at least 2-3 years with corn, small grains, alfalfa, or other non-host crops. Do not include soybeans in the rotation.

**White Mold (Timber Rot) of Multiple Crops -****Sclerotinia Fungus**

**Land selection** Beans (Dry), Beans (Fresh), Southern Peas/Cowpeas If possible, avoid fields with a history of disease problems.

**Contans WG® (Coniothyrium minitans)** Beans (Fresh)

1-4 lbs. per acre. See label for application methods. REI: 4-hour. PHI: 7-day. OMRI-listed.

**Aproach® (picoxystrobin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 8-12 fl. oz. per acre. REI: 12-hour. PHI: 14-day PHI.**Cannonball WG® (fludioxonil)** Beans (Dry), Beans (Fresh), Southern Peas/Cowpeas 7 oz. per acre. Do not exceed 28 oz. per year. REI: 12-hour. PHI: 7-day.**Endura® (boscalid)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 8-11 oz. per acre. REI: 12-hour. PHI: 7-day for fresh legumes, 21-day for dry legumes.**Fontelis® (pentiopyrad)** Beans (Dry), Lima Beans, Southern Peas/Cowpeas 16-20 fl. oz. per acre. REI: 12-hour. PHI: 0-day for fresh legumes, 21-day for dry legumes.**Fontelis® (pentiopyrad)** Beans (Fresh) 16-30 fl. oz. per acre. REI: 12-hour. PHI: 0-days.**Omega 500F® (fluazinam)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.5-0.85 pts. per acre. Do not exceed 1.75 pts. per acre per season. REI: see label. PHI: 14-day for fresh legumes, 30-day for dry legumes.**Proline 480SC® (prothioconazole)** Beans (Dry), Southern Peas/Cowpeas 5.7 fl. oz. per acre. REI: 12-hour. PHI: 7-day.**Rovral 4F® (iprodione)** Beans (Dry), Beans (Fresh), Lima Beans, Southern Peas/Cowpeas 1.5-2 pts. per acre. REI: 24-hour. PHI: 7-day.**Switch 62.5WG® (cyprodinil, fludioxonil)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 11-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.

**Topsin M WSB® (thiophanate-methyl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas REI: see label. PHI: 14-day for fresh, 28-day for dry legume.

**Vertisan® (pentiopyrad)** Beans (Dry), Southern Peas/Cowpeas 16-20 fl. oz. per acre. REI: 12. PHI: 21-day.

**Wilt of Multiple Crops - Fusarium Fungus**

**Crop rotation** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas Rotate away from legumes for several years to avoid build up of the Fusarium fungus.

**Variety selection** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas Use resistant cultivars.

**Weed Control****Recommended Controls****Burndown or Directed/Shielded Application****Broadleaf and Grass Weeds**

**glyphosate formulations (glyphosate)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations of 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before or after planting but before crop emerges, or apply up to 0.75 lb. acid equivalent between crop rows with wipers, hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. REI: 4-hour. PHI: 14-day.

**Gramoxone SL 2.0® (glyphosate)** Beans (Snap), Lima Beans, Peas (Fresh) 2-4 pts. per acre. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before seeding or after seeding but before crop emergence. RUP.

**Burndown or Directed/Shielded Application****Broadleaf Weeds**

**Aim EC® (carfentrazone)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.5-2 fl. oz. per acre. Apply prior to or within 24 hours after seeding, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour.

**Optill® (imazethapyr, saflufenacil)** See details below for Preemergence Broadleaf weeds.

**Sharpen® (saflufenacil)** 1.0-2.0 fl. oz. per acre. *Peas (Dry), and Chickpeas.* Surface apply as a burndown early pre-plant through preemergence. Add MSO at 1 pt. per acre when used as a pre-plant burndown. Do not apply group 14 (group E) herbicides within 30 days of planting. Do not apply when legumes reach cracking stage. REI: 12-hour.

**Spartan Charge® (carfentrazone, sulfentrazone)** See details below for Preemergence Broadleaf weeds.

### **Preemergence Broadleaf and Grass Weeds**

**Command 3ME® (clomazone)** *Beans (Fresh), Peas (Fresh)* 0.4-0.67 pt. per acre for beans. 1.3 pts. per acre for peas. Broadcast before planting, or after planting before crop emerges. Not effective on muck soil. REI: 12-hour. PHI: 45-day for beans.

**Dual Magnum® or Dual II Magnum® (s-metolachlor)** *Beans (Dry), Beans (Fresh), Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas* 1-2 pts. per acre. Use lower rates on coarse soils. Do not use on muck soils. **For peas** apply after seeding before crop emerges. Do not incorporate. **For beans and southern peas/cowpeas** apply and incorporate before planting, or apply after seeding but before crop emerges. For beans can be tank-mixed preplant incorporated with Eptam® or trifluralin. REI: 24-hour.

**Eptam® (EPTC)** *Beans (Dry), Beans (Fresh)* **Eptam 7E** at 3.5 pts. per acre or **20G** at 15 lbs. per acre. Apply before planting and incorporate immediately, or apply as a directed spray at last cultivation before pods start to form. Check label for sensitive types and varieties. Green beans and small white beans on coarse soils: Do not exceed 3.5 pts. 7E or 15 lbs. **20G** per acre. All other labeled crops: Do not exceed 9 pts. 7E per acre per crop. REI: 12-hour.

**Lorox DF® (linuron)** *Peas (Dry), Southern Peas/Cowpeas (Dry)* 1-2 lbs. per acre. Apply after seeding but before crop emerges. Do not apply to sand or loamy sand. Do not use on soils with less than 1% organic matter. REI: see label.

**Outlook® (dimethenamid-p)** 10-21 fl. oz. per acre. Use lower rate on coarse soils low in organic matter. Apply before planting and incorporate, apply after planting before emergence, or apply after planting when beans have 1-3 trifoliate leaves. Do not exceed 12 fl. oz. on coarse soils prior to emergence. REI: 12-hour. PHI: 70-day.

**pendimethalin formulations (pendimethalin)** *Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas* Use **3.3EC** formulations at 1.2-3.6 pts. per acre. Use **3.8ME** formulations at 1.5-3 pts. per acre. Use low rates on coarse soils. Broadcast and incorporate before planting. Not effective on soils with high organic matter. REI: 24-hour.

**Sonalan HFP® (ethalfluralin)** *Beans (Dry)* 1.5-4.5 pts. per acre. Apply and incorporate before planting. Use higher rates to suppress eastern black nightshade. Not for muck soils. REI: 24-hour.

**trifluralin formulations (trifluralin)** *Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas* 0.5-1 lb. a.i. per acre. Use **4EC** formulations at 1-1.5 pts. per acre for snap beans, lima beans, and peas, or up to 2 pts. per acre for dry beans. Use **10G** formulations at 5-7.5 lbs. per acre for snap beans, lima beans, and peas, or up to 10 lbs. per acre for dry beans. Broadcast and incorporate 1-2 inches before seeding. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour.

### **Preemergence Broadleaf Weeds**

**Optill® (imazethapyr, saflufenacil)** *Peas (Fresh), Peas (Dry)* 1.0-1.5 oz. per acre. Apply preplant, preplant incorporated or preemergence (up to 3 days after planting before cracking). Plant at least 1/2 inch deep to avoid injury. For English peas in Illinois, Iowa and Minnesota check label for precautions. In Michigan do not apply more than 1 oz. per acre on sand or loamy sand soils preplant burndown or preemergence. Do not apply north of Highway 210 in Minnesota. Do not use on any *Phaseolus* bean species. Do not apply group 14 (group E) herbicides within 30 days of planting. REI: 12-hour.

**Reflex® (fomesafen)** *Peas (Fresh)* 1 pt. per acre. *Michigan only* — applicators must have a 24c label. Label expires Dec 31, 2023. See next Preemergence and Postemergence Broadleaf Weeds section for uses on beans. Apply in a tank-mix with other herbicides after seeding peas and before emergence. Use only once in 2 years on same soil. 18-month waiting period before planting most other crops. REI: 24-hour. PHI: 46-day.

**Sharpen® (saflufenacil)** *Peas (Fresh), Lentils.* For fresh peas in Illinois, Iowa, Michigan, Minnesota, and Wisconsin apply 0.75 fl. oz. per acre rate preplant incorporated or preemergence (up to 3 days after planting before cracking). For lentils in Minnesota

use up to 2.0 fl. oz. per acre. Suppresses black nightshade, lambsquarters, pigweed, and velvetleaf. Higher rates in lentils and chickpeas will provide more, but still limited, residual weed control. Plant legumes at least 1/2-inch deep to avoid injury. Do not apply group 14 (group E) herbicides within 30 days of planting. REI: 12-hour.

**Spartan 4F® (sulfentrazone) Peas, (Dry), Chickpea,**  
2.25-8.0 fl. oz. per acre. Spring-apply early-preplant, preplant-incorporated, or preemergence (up to 3 days after planting before cracking). Rate depends on soil texture, organic matter, and pH. Do not use on sand soils with less than 1% organic matter or apply after crop emerges. Michigan, Minnesota, and Wisconsin only -- a fall application before soil freezes is allowed. REI: 12-hour.

#### **Spartan Charge® (carfentrazone, sulfentrazone)**

*Peas (Dry), Chickpea* 3.0-10.2 fl. oz. per acre. Apply preplant-burndown, early-preplant, or preemergence. Do not use on coarse soils with less than 1% soil organic matter.

Rate for labeled crops depends on soil texture, organic matter, and pH. Do not apply after crop emerges. REI: 12-hour.

#### **Preemergence and Postemergence Broadleaf Weeds**

**Permit® (halosulfuron) Beans (Dry)** 0.5-1.0 oz. per acre. Use 0.5-0.66 oz. per acre for preemergence and postemergence broadcast or directed sprays, or up to 1.0 oz. per acre for row-middle applications with no crop contact. Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Do not exceed 1 oz. per acre per crop cycle, or 2 oz. per acre per 12-month period. REI: 12-hour.

#### **Pursuit (imazethapyr)**

*Beans (Dry), Chickpeas, Lima Beans, Peas (Fresh), Peas (Dry), Southern Peas/Cowpeas* 3 fl. oz. per acre or up to 4 fl. oz. per acre for Southern Peas/ Cowpeas. Apply and incorporate within 1 week of planting, or apply within 3 days after planting before crop emerges. For dry beans and peas only, a postemergence application may be made after beans have 1 fully expanded trifoliate leaf or peas or cowpeas are at least three inches tall. Use 8 oz. of NIS per 25 gals. of spray solution if emerged weeds are present. If using COC or N fertilizer on dry beans to improve weed control, add Basagran® at 6-16 fl. oz. per acre or Rezult® at 12-24 fl. oz. per acre to minimize crop injury. Do not apply to fields treated with trifluralin or injury may occur.

In Minnesota north of Highway 210 and in Michigan on sandy or sandy loam soils do not apply more than 2 fl. oz. per acre.

*Beans (Fresh)* in Illinois, Indiana, Iowa, Minnesota, Michigan and Wisconsin 1.5 fl. oz. per acre. Apply and incorporate within 1 week of planting, or apply within 1 day after planting. Apply before July 31.

REI: 4-hour. PHI: 30-day for snap beans, succulent lima beans, peas, and southern peas/cowpeas or when tank mixed with Basagran® or Rezult®. 60-day for chickpeas, dry beans, dry peas.

**Reflex® (fomesafen) Beans (Dry), Beans (Fresh)**. Reflex is labeled in all states participating in this publication except in Kansas west of Highway 281 and in Minnesota north of Highway 2. Extreme southeast Missouri (Region 1): 1.5 pts. per acre year. Indiana, Illinois, and Ohio south of I-70 (Region 2): 1.5 pts. per acre in alternate years. Indiana, Illinois, and Ohio north of I-70 (Region 3); and the rest of Missouri: 1.25 pts. per acre in alternate years. Kansas east of Highway 281 and Michigan and Minnesota south of I-94 (Region 4): 1 pt. per acre in alternate years. Minnesota south of Highway 2 and north of I-94 (Region 5): 0.75 pt. per acre in alternate years. Preplant and preemergence applications are labeled for Regions 1, 2, 3, and 4. Postemergence applications are labeled for Regions 1, 2, 3, 4, and 5. Apply postemergence when dry beans or snap beans have at least one fully expanded trifoliate leaf, and use NIS, COC, or other additives following label instructions. Do not use liquid nitrogen or ammonium sulfate as an additive. REI: 24-hour. PHI: 30-day for snap beans; 45-day for dry beans.

#### **Sandea® (halosulfuron)**

*Beans, Dry*: 0.5-0.67 oz. per acre, up to 1 oz. per acre for row-middle applications with no crop contact.

*Beans (Fresh), Lima Beans*. 0.5-1.0 oz. per acre preemergence or row-middle applications with no crop contact. 0.5-0.67 oz. per acre postemergence over top of crop.

*Shelled Peas (Fresh), Southern Peas/Cowpeas*. 0.5 oz. per acre for preemergence application; up to 1 oz. per acre for postemergence application; directed sprays recommended.

**For all crops:** Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present at time of preemergence application. Use lower rates on coarse soils with low organic matter. Apply after

**Herbicides for Legumes<sup>1</sup>**

Products (REI/PHI)	Common Name	Timing and Application Location Relative to Crop <sup>2</sup>		Weed Groups Controlled	Crops <sup>3</sup>	
		Timing Relative to Weeds	Relative to Crop <sup>2</sup>		Incorporated	Postemergence
Aim EC <sup>®</sup> (12h/-)	carfentrazone	X	X	X	X	X
Assure II <sup>®</sup> (12h/15d to 60d)	quizalofop		X	X	X	X
Basagran <sup>®</sup> (12h/30d)	benazon		X		X	X
Command 3ME <sup>®</sup> (12h/45d)	clomazone	X	X		X	X
Dual Magnum <sup>®</sup> (12h/-)	napropamide	X	X	Variable	X	X
Eptam <sup>®</sup> (12h/-)	EPTC	X	X	Yes	X	X
Gramoxone <sup>®</sup> (12h to 24h/-)	paraquat	X	X		X	X
MicroTech <sup>®</sup>	alachlor	X		Yes	X	X
Optill <sup>®</sup> (12h/0)	saflufenacil + imazethapyr	X	X		X	X
Outlook <sup>®</sup> (12h/70d)	dimethenamid-P	X	X	Yes	X	X
Pendimethalin (-/0d)	pendimethalin	X		Yes	X	X
Permit <sup>®</sup> (12h/30 to 60d)	halosulfuron	X	X		X	X
Poast <sup>®</sup> (12h/15-30d)	sethoxydim	X			X	X
Pursuit <sup>®</sup> (12h/30d)	imazethapyr	X	X		X	X
Raptor <sup>®</sup> (4h/0-30d)	imazamox	X			X	X
Reflex <sup>®</sup> (12h/30d to 45d)	fomesafen	X			X	X
Roundup <sup>®</sup> , others (12h/14d)	glyphosate	X	X		X	X
Sandea <sup>®</sup> (12h/30d)	halosulfuron)	X	X		X	X
Select Max <sup>®</sup> , others (12h/21-30d)	clethodim	X			X	X
Sharpen <sup>®</sup> (12h/0d)	saflufenacil	X	X		X	X
Sonalan <sup>®</sup>	ethalfluralin	X		Yes	X	X
Spartan 4F <sup>®</sup> (12h/-)	sulfentrazone	X	X		X	X
Spartan Advance <sup>®</sup> (12h/90d)	sulfentrazone + glyphosate	X	X		X	X
Spartan Charge <sup>®</sup> (12h/-)	sulfentrazone + carfentrazone	X	X		X	X
Targa <sup>®</sup> (12h/15d to 60 d)	quizalofop		X		X	X
Thistrol (24h/-)	MCPB	X			X	X
Treflan <sup>®</sup> , others (12h/-)	trifluralin	X		Yes	X	X

<sup>1</sup>For effectiveness against specific weeds, see Relative Effectiveness of Herbicides for Vegetable Crops (page 68), and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbicides can cause serious crop injury and yield loss if not used properly.

<sup>2</sup>X=permitted for at least one crop.

<sup>3</sup>X= permitted on this crop in at least one state.

planting but prior to cracking, postemergence broadcast, or postemergence directed spray.

For dry beans make postemergence applications after plants have 1-3 trifoliate leaves but before flowering.

For snap beans or lima beans make postemergence applications after plants have 2-4 trifoliate leaves but before flowering; directed spray may limit injury.

For southern peas/cowpeas make postemergence applications using a directed spray when plants have 3-4 trifoliate leaves but before flowering.

Not recommended when temperatures are cool due to potential for crop injury. Row-middle applications with no crop contact may reduce crop injury after crop emergence. Do not exceed 1 oz. per acre per crop cycle or 2 oz. per acre per 12-month period. REI: 12-hour. PHI: 30-day.

### **Postemergence Broadleaf and Grass Weeds**

#### **Raptor (imazamox)**

*Beans (Dry, see label for specific types), Peas (Dry) 4 fl. oz. per acre. May add 1-2 gals. of COC, or 1 qt. of NIS plus 2.5 gals. of nitrogen or 12-15 lbs. ammonium sulfate per 100 gals. of spray solution to improve weed control (but may increase crop injury). If using COC or N fertilizer on dry beans to improve weed control, add Basagran® at 6-16 fl. oz. per acre or Rezult® at 12-24 fl. oz. per acre to minimize crop injury. You must add Basagran® or Rezult® for dry peas regardless of additives. A reduced 2 oz. per acre rate of Raptor® tank-mixed with Rezult® is labeled for control of mustard species in Minnesota for dry bean and dry peas.*

*Snap beans (IL, IN, IA, MI, MN, WI): 4 fl. oz. per acre. Must be applied with Basagran® at 6-16 fl. oz. per acre to improve crop tolerance. Apply after the first trifoliate is fully expanded and before bloom. Must add NIS containing at least 80% active ingredient at 1 qt. per 100 gals. of spray solution. Do not add crop oils.*

*Lima beans (succulent) (IL, IN, IA, MI, MN, boot heel of MO, WI): 4 fl. oz. per acre. Must be applied with Basagran® at 6-16 fl. oz. per acre to improve crop tolerance. Apply when lima beans are in the first or second trifoliate and weeds are less than 3 inches. Do not apply during flowering. Must add NIS containing at least 80% active ingredient at 1 qt. per 100 gals. of spray solution.*

*Peas (Fresh) (English pea). (IL, IN, IA, MI, MN, WI):*

*3 fl. oz. per acre. Apply to peas at least 3 inches tall but prior to 5 nodes before flowering. Must add NIS containing at least 80% active ingredient at 1 qt. per 100 gals. of spray solution. Adding a nitrogen-based solution may improve weed control but may also increase crop injury. May add Basagran® at 6-16 fl. oz. per acre to improve crop safety and broadleaf weed control when using N-based fertilizer. The 3 oz. rate of Raptor is weak on grasses. May use COC instead of NIS to improve activity on grasses, but always add Basagran® to improve crop safety when using COC. Using Raptor on fields treated with trifluralin may increase the risk of injury.*

*All Crops Labeled: Do not exceed 1 application per year. REI: 4-hour. PHI: 30-day when tank mixed with Basagran® or Rezult®.*

#### **Rezult® (bentazon, sethoxydim) Beans (Dry), Peas (Dry)**

*3.2 pts. per acre. Apply when weeds are small and after peas have 3 pairs of leaves or first trifoliate leaf of beans is fully expanded. An additional application of Basagran® is allowed not to exceed 2 pts. per acre. An additional application of Poast is allowed at 2.9 pts. per acre. REI: 48-hour. PHI: 30-day.*

### **Postemergence Broadleaf Weeds**

**Basagran® (bentazon)** *Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh)* Basagran 4L® at 1.5 to 2.0 pts. per acre, or Basagran 5L® at 1.2-1.6 pts. per acre. Apply when weeds are small and after peas have 3 pairs of leaves or first trifoliate leaf of beans is fully expanded. Do not add COC for peas. Do not exceed 4 pts. of 4L per acre per season. Do not exceed 3.6 pts. of 5L per acre per season. REI: 48-hour. PHI: 30-day.

**Thistrol® (MCPB)** *Peas (Dry), Peas (Fresh) 1-2 qts. per acre. Controls Canada thistle. Apply when peas have 6-12 nodes. Do not apply later than 3 nodes before pea flowering or after pea flower buds appear. Do not apply when peas are stressed or when temperature exceeds 90°F. REI: see label.*

### **Postemergence Grass Weeds**

**Assure II® (quizalofop)** *Beans (Dry), Beans (Fresh), Peas (Dry), Peas (Fresh), 5-12 fl. oz. per acre. Use 1 qt. of COC per acre. Apply to actively growing grass. Do not exceed 14 fl. oz. per acre. REI: 12-hour. PHI: 15-day for snap beans, 30-day for dry beans and succulent peas, 60-day for dry peas.*

**clethodim formulations (clethodim)** *Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas* Use 2EC formulations at 6-16 fl. oz. per acre with 1 qt. of COC per 25 gals.

of spray solution (1% v/v). Use Select Max® at 9-32 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Use low rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations per acre per season. Do not exceed 64 fl. oz. of Select Max® per acre per season. REI: 24-hour. PHI: 21-day for snap beans, lima beans, peas, southern peas/cowpeas; 30-day for dry beans, peas, lima beans, southern peas/cowpeas.

**Fusilade DX® (fluazifop-P) Beans (Dry)** 8-12 fl. oz. per acre. Include 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gals. of spray solution. Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 48 fl. oz. per acre per season. REI: 12-hour. PHI: 60-day.

**Poast® (sethoxydim)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1-2.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4 pts. per acre per season. REI: 12-hour. PHI: 15-day for succulent legumes, 30-day for dry legumes.

**Targa® (quizalofop)** Beans (Dry), Beans (Fresh), Peas (Dry), Peas (Fresh) 5-12 fl. oz. per acre. Use 1 qt. of COC per acre. Apply to actively growing grass. Do not exceed 14 fl. oz. per acre. REI: 12-hour. PHI: 15-day for snap beans, 30-day for dry beans and succulent peas, 60-day for dry peas.

## Insect Control

### Recommended Controls

#### Aphids

**M-Pede® (potassium salts of fatty acids)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1-2% by volume. To achieve enhanced and residual pest control mix with a labeled companion insecticide. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Admire Pro® (imidacloprid)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 7-10.5 fl. oz. per acre soil application, or 1.2 fl. oz. per acre foliar application. Do not exceed 1 soil application per season or 3 foliar applications per season. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application.

**Asana XL® (esfenvalerate)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/

Cowpeas 5.8-9.6 fl. oz. per acre. Do not exceed 38.4 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for fresh legumes, 21-day for dry legumes. RUP.

**Assail 30SG® (acetamiprid)** Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas 2.5-5.3 oz. per acre. Do not exceed 3 applications per season or more than once every 7 days. REI: 12-hour. PHI: 7-day.

**Brigade 2EC® (bifenthrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.1-6.4 fl. oz. per acre. Treat Mexican Bean Leaf Beetle on dry peas and beans only. Do not exceed 12.8 fl. oz. per acre per season. Allow 3 days between applications on fresh legumes. Allow 7 days between applications on dry legumes. REI: 12-hour. PHI: 3-day for fresh legumes, or 14-day for dry legumes. RUP.

**Cruiser 5FS® (thiamethoxam)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45 days of planting treated seed. REI: 12-hour.

**Dimethoate 4EC® (dimethoate)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh) 0.5-1.0 pt. per acre. Do not exceed 2 pts. per acre per season. Do not feed or graze livestock on treated plants. See pollinator precautions. Mechanical harvest only on day of application. Not for use on Cowpeas/Southern Peas. REI: 48-hour. PHI: 0-day.

**Lannate LV® (methomyl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.5-3 pts. per acre. Do not exceed 15 pts. per acre per season. Do not feed or graze livestock on treated plants within 7 days of application for succulent legumes, or 14 days of application for dry legumes. REI: 48-hour. PHI: 1-day at rates less than 1.5 pts. per acre, or 3-day for rates over 1.5 pts. per acre on fresh legumes, or 14-day for any rate on dry legumes. RUP.

**Movento® (spirotetramat)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 4.0-5.0 fl. oz. per acre. Do not exceed 5 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day for fresh legumes, or 7-day for dry legumes.

**Mustang Maxx® (zeta-cypermethrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.72-4.0 fl. oz. Do not exceed 24. fl. oz. per acre per season. REI: 12-hour. PHI: 1-day for fresh legumes, or 21-day for dry legumes. RUP.

**Orthene 97 Soluble® (acephate)** Beans (Dry), Lima Beans 0.5-1.0 lb. per acre. Do not exceed 2 1/8 lbs. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 1-day for fresh Lima Beans, or 14-day for dry legumes.

**Sivanto 200SL® (flupyradifurone)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 7-10.5 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. Allow 10 days between applications. REI: 4-hour. PHI: 7-day.

**Thimet 20G® (phorate)** Beans (Dry), Beans (Fresh), Lima Beans 4.5-7.0 oz. per 1,000 ft. of row. Drill granules to the side of the seed or in a band over the row and lightly incorporate with a drag chain. Granules must be incorporated into the soil. Do not place granules in direct contact with seed. Do not feed or graze livestock on treated plants. REI: 48-hour. PHI: 60-day. RUP.

**Warrior II® (lambda-cyhalothrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 7-day for fresh legumes, or 21-day for dry legumes. RUP.

### **Bean Leaf Beetle**

Treatment for Bean Leaf Beetle is warranted at a threshold of 1 beetle per foot of row.

**Baythroid XL® (beta-cyfluthrin)** Beans (Dry), Peas (Dry), Southern Peas/Cowpeas 2.4-3.2 fl. oz. per acre. Do not exceed 6.4 fl. oz. per acre per season for succulent Cowpeas/Southern Peas, or 10.5 fl. oz. per acre per season for dry legumes. Allow 14 days between applications. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for Cowpeas/Southern Peas, or 7-day for dry legumes. RUP.

**Brigade 2EC® (bifenthrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.1-6.4 fl. oz. per acre. Treat Mexican Bean Leaf Beetle on dry peas and beans only. Do not exceed 12.8 fl. oz. per acre per season. Allow 3 days between applications on fresh legumes. Allow 7 days between applications on dry legumes. REI: 12-hour. PHI: 3-day for fresh legumes, or 14-day for dry legumes. RUP.

**Cruiser 5FS® (thiamethoxam)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28 fl. oz. per 100 lbs. of

seed. Do not apply a neonicotinoid insecticide within 45 days of planting treated seed. REI: 12-hour.

**Dimethoate 4EC® (dimethoate)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh) 0.5-1.0 pt. per acre. Do not exceed 2 pts. per acre per season. Do not feed or graze livestock on treated plants. See pollinator precautions. Mechanical harvest only on day of application. Not for use on Cowpeas/Southern Peas. REI: 48-hour. PHI: 0-day.

**Mustang Maxx® (zeta-cypermethrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.72-4.0 fl. oz. Do not exceed 24. fl. oz. per acre per season. REI: 12-hour. PHI: 1-day for fresh legumes, or 21-day for dry legumes. RUP.

**Orthene 97 Soluble® (acephate)** Beans (Dry), Lima Beans 0.5-1.0 lb. per acre. Do not exceed 2 1/8 lbs. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 1-day for fresh Lima Beans, or 14-day for dry legumes.

**Sevin XLR Plus® (carbaryl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.5-1.0 qts. per acre. Do not exceed 6 qts. per acre per season. Do not use on shelled succulent peas and beans. Edible-pod succulent and dried shelled beans and peas only. REI: 12-hour. PHI: 3-day for fresh legumes, 14-day for dry legumes.

**Warrior II® (lambda-cyhalothrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 7-day for fresh legumes, or 21-day for dry legumes. RUP.

### **Caterpillars**

There are many caterpillar pests of legumes, including European corn borer, corn earworm/tomato fruitworm, alfalfa caterpillars, cutworms, loopers, and armyworms. Always check the label for the specific list of caterpillars that the product can be used on.

**Asana XL® (esfenvalerate)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 5.8-9.6 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 38.4 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for fresh legumes, 21-day for dry legumes. RUP.

**Baythroid XL® (beta-cyfluthrin)** Beans (Dry), Peas (Dry), Southern Peas/Cowpeas 0.8-3.2 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 6.4 fl. oz. per acre per season for succulent Cowpeas/

OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.

Southern Peas, or 10.5 fl. oz. per acre per season for dry legumes. Allow 14 days between applications. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for Cowpeas/Southern Peas, or 7-day for dry legumes. *RUP*.

**Blackhawk® (spinosad)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.7-3.3 oz. per acre. Check label for specific caterpillars. Do not exceed 6 applications per season. Allow 5 days between applications. Do not feed or graze livestock on treated plants. REI: 4-hour. PHI: 3-day for fresh legumes, or 28-day for dry legumes.

**Brigade 2EC® (bifenthrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.1-6.4 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 12.8 fl. oz. per acre per season. Allow 3 days between applications on fresh legumes. Allow 7 days between applications on dry legumes. REI: 12-hour. PHI: 3-day for fresh legumes, or 14-day for dry legumes. *RUP*.

**Coragen® (chlorantraniliprole)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 3.5-7.5 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 15.4 fl. oz. per acre per season. Allow 3 days between applications. REI: 4-hour. PHI: 1-day.

**Entrust SC® (spinosad)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 3-6 oz. per acre. Check label for specific caterpillars. Do not exceed 29 oz. per acre per season for succulent legumes, or 12 oz. per acre per season for dry legumes. Do not feed or graze livestock on treated plants. REI: 4-hour. PHI: 3-day for fresh legumes, or 28-day for dry legumes. *OMRI-listed*.

**Intrepid 2F® (methoxyfenozide)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 4-16 fl. oz. per acre. Check label for specific caterpillars. Use 4-8 fl. oz. on young plants in early season. Use 8-16 fl. oz. for mid- to late-season applications or heavier infestations. Do not exceed 64 fl. oz. per acre per season. Allow 7 days between applications. REI: 4-hour. PHI: 7-day.

**Lannate LV® (methomyl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.5-3 pts. per acre. Check label for specific caterpillars. Do not exceed 15 pts. per acre per season. Do not feed or graze livestock on treated plants within 7 days of application for succulent legumes, or 14 days of application for dry legumes. REI: 48-hour. PHI: 1-day at rates less than 1.5 pts. per acre, or 3-day for rates over 1.5 pts. per acre on fresh legumes, or 14-day for any rate on dry legumes. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.72-4.0 fl. oz. Check label for specific caterpillars. Do not exceed 24. fl. oz. per acre per season. REI: 12-hour. PHI: 1-day for fresh legumes, or 21-day for dry legumes. *RUP*.

**Orthene 97 Soluble® (acephate)** Beans (Dry), Lima Beans 0.5-1.0 lb. per acre. Check label for specific caterpillars. Do not exceed 2 1/8 lbs. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 1-day for fresh Lima Beans, or 14-day for dry legumes.

**Radiant 1SC® (spinetoram)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 3-8 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 28 fl. oz. per acre per season for succulent legumes, or 12 fl. oz. per acre for dry legumes. REI: 4-hour. PHI: 3-day for fresh legumes, or 28-day for dry legumes.

**Sevin XLR Plus® (carbaryl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.5-1.5 qts. per acre. Check label for specific caterpillars. Do not exceed 6 qts. per acre per season. Do not use on shelled succulent peas and beans. Edible-pod succulent and dried shelled beans and peas only. REI: 12-hour. PHI: 3-day for fresh legumes, 14-day for dry legumes.

**Warrior II® (lambda-cyhalothrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28-1.92 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 7.68 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 7-day for fresh legumes, or 21-day for dry legumes. *RUP*.

### **Cowpea Curculio Beetle**

**Asana XL® (esfenvalerate)** Beans (Dry), Peas (Dry) 4.8-9.6 fl. oz. per acre. Do not exceed 38.4 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 21-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** Beans (Dry), Peas (Dry), Southern Peas/Cowpeas 1.6-2.4 fl. oz. per acre. Do not exceed 6.4 fl. oz. per acre per season for succulent Cowpeas/Southern Peas, or 10.5 fl. oz. per acre per season for dry legumes. Allow 14 days between applications. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for Cowpeas/Southern Peas, or 7-day for dry legumes. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.72-4.0 fl. oz. Do not exceed 24. fl. oz.

per acre per season. REI: 12-hour. PHI: 1-day for fresh legumes, or 21-day for dry legumes. *RUP*.

**Sevin XLR Plus® (carbaryl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.5-1.5 qts. per acre. Do not exceed 6 qts. per acre per season. Do not use on shelled succulent peas and beans. Edible-pod succulent and dried shelled beans and peas only. REI: 12-hour. PHI: 3-day for fresh legumes, 14-day for dry legumes.

**Warrior II® (lambda-cyhalothrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 7-day for fresh legumes, or 21-day for dry legumes. *RUP*.

### **Leafhoppers**

Treatment for potato leafhopper is warranted at the following thresholds.

*Seedlings*: 0.5 per sweep, or 2 per row foot.

*3rd trifoliolate*: 1 per sweep, or 5 per row foot.

*Bud stage*: 5 per row foot.

**M-Pede® (potassium salts of fatty acids)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1-2% by volume. To achieve enhanced and residual pest control mix with a labeled companion insecticide. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Admire Pro® (imidacloprid)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 7-10.5 fl. oz. per acre soil application, or 1.2 fl. oz. per acre foliar application. Do not exceed 1 soil application per season or 3 foliar applications per season. REI: 12-hour. PHI: 21-day for soil application, or 7-day for foliar application.

**Asana XL® (esfenvalerate)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 5.8-9.6 fl. oz. per acre. Do not exceed 38.4 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for fresh legumes, 21-day for dry legumes. *RUP*.

**Assail 30SG® (acetamiprid)** Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas 2.5-5.3 oz. per acre. Do not exceed 3 applications per season or more than once every 7 days. REI: 12-hour. PHI: 7-day.

*OMRI-listed* indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.

**Baythroid XL® (beta-cyfluthrin)** Beans (Dry), Peas (Dry), Southern Peas/Cowpeas 0.8-1.6 fl. oz. per acre. Do not exceed 6.4 fl. oz. per acre per season for succulent Cowpeas/Southern Peas, or 10.5 fl. oz. per acre per season for dry legumes. Allow 14 days between applications. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for fresh Cowpeas/Southern Peas, or 7-day for dry legumes. *RUP*.

**Brigade 2EC® (bifenthrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.6-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. Allow 3 days between applications on fresh legumes. Allow 7 days between applications on dry legumes. REI: 12-hour. PHI: 3-day for fresh legumes, or 14-day for dry legumes. *RUP*.

**Cruiser 5FS® (thiamethoxam)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45 days of planting treated seed. REI: 12-hour.

**Dimethoate 4EC® (dimethoate)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh) 0.5-1.0 pt. per acre. Do not exceed 2 pts. per acre per season. Do not feed or graze livestock on treated plants. See pollinator precautions. Mechanical harvest only on day of application. Not for use on Cowpeas/Southern Peas. REI: 48-hour. PHI: 0-day.

**Lannate LV® (methomyl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.75-3 pts. per acre. Do not exceed 15 pts. per acre per season. Do not feed or graze livestock on treated plants within 7 days of application for succulent legumes, or 14 days of application for dry legumes. REI: 48-hour. PHI: 1-day at rates less than 1.5 pts. per acre, or 3-day for rates over 1.5 pts. per acre on fresh legumes, or 14-day for any rate on dry legumes. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.72-4.0 fl. oz. Do not exceed 24. fl. oz. per acre per season. REI: 12-hour. PHI: 1-day for fresh legumes, or 21-day for dry legumes. *RUP*.

**Orthene 97 Soluble® (acephate)** Beans (Dry), Lima Beans 0.5-1.0 lb. per acre. Do not exceed 2 1/8 lbs. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 1-day for fresh Lima Beans, or 14-day for dry legumes.

**Sivanto 200SL® (flupyradifurone)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 7-10.5 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. Allow 10 days

between applications. REI: 4-hour. PHI: 7-day.

**Thimet 20G® (phorate)** Beans (Dry), Beans (Fresh), Lima Beans 4.5-7.0 oz. per 1,000 ft. of row. Drill granules to the side of the seed or in a band over the row and lightly incorporate with a drag chain. Granules must be incorporated into the soil. Do not place granules in direct contact with seed. Do not feed or graze livestock on treated plants. REI: 48-hour. PHI: 60-day. RUP.

**Warrior II® (lambda-cyhalothrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 7-day for fresh legumes, or 21-day for dry legumes. RUP.

### **Mexican Bean Beetle**

Treatment for Mexican Bean Beetle is warranted at a threshold of 0.5 beetle per plant.

**Asana XL® (esfenvalerate)** Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas 2.9-5.8 fl. oz. per acre. Do not exceed 38.4 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for succulent legumes, 21-day for dry legumes. RUP.

**Baythroid XL® (beta-cyfluthrin)** Beans (Dry), Peas (Dry), Southern Peas/Cowpeas 2.4-3.2 fl. oz. per acre. Do not exceed 6.4 fl. oz. per acre per season for succulent Cowpeas/Southern Peas, or 10.5 fl. oz. per acre per season for dry legumes. Allow 14 days between applications. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for Cowpeas/Southern Peas, or 7-day for dry legumes. RUP.

**Brigade 2EC® (bifenthrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.1-6.4 fl. oz. per acre. Treat Mexican Bean Leaf Beetle on dry peas and beans only. Do not exceed 12.8 fl. oz. per acre per season. Allow 3 days between applications on fresh legumes. Allow 7 days between applications on dry legumes. REI: 12-hour. PHI: 3-day for fresh legumes, or 14-day for dry legumes. RUP.

**Cruiser 5FS® (thiamethoxam)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45 days of planting treated seed. REI: 12-hour.

**Dimethoate 4EC® (dimethoate)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh) 0.5-1.0 pt. per acre. Do not exceed 2 pts. per acre per season.

Do not feed or graze livestock on treated plants. See pollinator precautions. Mechanical harvest only on day of application. Not for use on Cowpeas/Southern Peas. REI: 48-hour. PHI: 0-day.

**Lannate LV® (methomyl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.75-3 pts. per acre. Do not exceed 15 pts. per acre per season. Do not feed or graze livestock on treated plants within 7 days of application for succulent legumes, or 14 days of application for dry legumes. REI: 48-hour. PHI: 1-day at rates less than 1.5 pts. per acre, or 3-day for rates over 1.5 pts. per acre on fresh legumes, or 14-day for any rate on dry legumes. RUP.

**Mustang Maxx® (zeta-cypermethrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.72-4.0 fl. oz. Do not exceed 24. fl. oz. per acre per season. REI: 12-hour. PHI: 1-day for fresh legumes, or 21-day for dry legumes. RUP.

**Orthene 97 Soluble® (acephate)** Beans (Dry), Lima Beans 0.5-1.0 lb. per acre. Do not exceed 2 1/8 lbs. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 1-day for fresh Lima Beans, or 14-day for dry legumes.

**Sevin XLR Plus® (carbaryl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.5-1.0 qts. per acre. Do not exceed 6 qts. per acre per season. Do not use on shelled succulent peas and beans. Edible-pod succulent and dried shelled beans and peas only. REI: 12-hour. PHI: 3-day for fresh legumes, 14-day for dry legumes.

**Thimet 20G® (phorate)** Beans (Dry), Beans (Fresh), Lima Beans 4.9-9.4 oz. per 1,000 ft. of row. Drill granules to the side of the seed or in a band over the row and lightly incorporate with a drag chain. Granules must be incorporated into the soil. Do not place granules in direct contact with seed. Do not feed or graze livestock on treated plants. REI: 48-hour. PHI: 60-day. RUP.

**Warrior II® (lambda-cyhalothrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.96-1.6 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 7-day for fresh legumes, or 21-day for dry legumes. RUP.

### **Mites**

**Acramite 50WS® (bifenazate)** Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas 1-1.5 lbs. per acre. Do not exceed 2 applications per season. REI: 12-hour. PHI: 3-day.

**Agri-Mek SC® (abamectin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.75-3.5 fl. oz. per acre. Not for use on cowpeas grown for fresh use. Do not exceed 10.25 fl. oz. per acre per season and do not make more than 2 sequential applications. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 7-day. RUP.

**Portal® (fenpyroximate)** Beans (Fresh) 2 pts. per acre. Do not exceed 4 pts. per acre per season. REI: 12-hour. PHI: 1-day.

### Pea Weevil Beetle

**Baythroid XL® (beta-cyfluthrin)** Beans (Dry), Peas (Dry), Southern Peas/Cowpeas 2.4-3.2 fl. oz. per acre. Do not exceed 6.4 fl. oz. per acre per season for succulent Cowpeas/Southern Peas, or 10.5 fl. oz. per acre per season for dry legumes. Allow 14 days between applications. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for Cowpeas/Southern Peas, or 7-day for dry legumes. RUP.

**Brigade 2EC® (bifenthrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.1-6.4 fl. oz. per acre. Treat Mexican Bean Leaf Beetle on dry peas and beans only. Do not exceed 12.8 fl. oz. per acre per season. Allow 3 days between applications on fresh legumes. Allow 7 days between applications on dry legumes. REI: 12-hour. PHI: 3-day for fresh legumes, or 14-day for dry legumes. RUP.

**Mustang Maxx® (zeta-cypermethrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.72-4.0 fl. oz. Do not exceed 24. fl. oz. per acre per season. REI: 12-hour. PHI: 1-day for fresh legumes, or 21-day for dry legumes. RUP.

**Sevin XLR Plus® (carbaryl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.5-1.5 qts. per acre. Do not exceed 6 qts. per acre per season. Do not use on shelled succulent peas and beans. Edible-pod succulent and dried shelled beans and peas only. REI: 12-hour. PHI: 3-day for fresh legumes, 14-day for dry legumes.

**Warrior II® (lambda-cyhalothrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 7-day for fresh legumes, or 21-day for dry legumes. RUP.

### Seed and Root Maggots

Flies are attracted to rotting organic material and freshly plowed soil.

**Correct planting time** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas Plant after the peak flight and egg-laying window of the first generation of flies looking to lay eggs around 360 GDD base 40.

**Healthy plant material** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas NA Handle seeds carefully to prevent cracking.

**Moldboard plow** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas Plow winter vegetation under early in the spring and thoroughly cover to limit attractiveness of rotting vegetation to the first generation of flies to lay eggs on.

**Capture LFR® (bifenthrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.2-0.39 fl. oz. per 1,000 ft. of row. Apply as a 5-7 inch band over the row on the soil surface, open furrow, or in-furrow at planting. REI: 12-hour. RUP.

**Cruiser 5FS® (thiamethoxam)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45 days of planting treated seed. REI: 12-hour.

**Lorsban 4E® (chlorpyrifos)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2 pts. per acre or 1.8 fl. oz. per 1,000 ft. of row. For planting applications, spray 3-5 inch band over row behind planter show and in front of press wheel to achieve shallow incorporation. REI: see label. RUP.

**Thimet 20G® (phorate)** Beans (Dry), Beans (Fresh), Lima Beans 4.5-7.0 oz. per 1,000 ft. of row. Drill granules to the side of the seed or in a band over the row and lightly incorporate with a drag chain. Granules must be incorporated into the soil. Do not place granules in direct contact with seed. Do not feed or graze livestock on treated plants. REI: 48-hour. PHI: 60-day. RUP.

### Stink Bugs

**Baythroid XL® (beta-cyfluthrin)** Beans (Dry), Peas (Dry), Southern Peas/Cowpeas 1.6-2.4 fl. oz. per acre. Do not exceed 6.4 fl. oz. per acre per season for succulent Cowpeas/Southern Peas, or 10.5 fl. oz. per acre per season for dry legumes. Allow 14 days between applications. Do not feed or graze livestock on treated plants. REI: 12-hour. PHI: 3-day for Cowpeas/Southern Peas, or 7-day for dry legumes. RUP.

**Brigade 2EC® (bifenthrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.1-6.4 fl. oz. per acre. Treat Mexican Bean Leaf Beetle on dry peas and beans only. Do not exceed 12.8 fl. oz. per acre per season. Allow 3 days between applications on fresh legumes. Allow 7 days between applications on dry legumes. REI: 12-hour. PHI: 3-day for fresh legumes, or 14-day for dry legumes. RUP.

**Lannate LV® (methomyl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.5-3 pts. per acre. Do not exceed 15 pts. per acre per season. Do not feed or graze livestock on treated plants within 7 days of application for succulent legumes, or 14 days of application for dry legumes. REI: 48-hour. PHI: 1-day at rates less than 1.5 pts. per acre, or 3-day for rates over 1.5 pts. per acre on fresh legumes, or 14-day for any rate on dry legumes. RUP.

**Mustang Maxx® (zeta-cypermethrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.72-4.0 fl. oz. Do not exceed 24. fl. oz. per acre per season. REI: 12-hour. PHI: 1-day for fresh legumes, or 21-day for dry legumes. RUP.

**Sevin XLR Plus® (carbaryl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.5-1.5 qts. per acre. Do not exceed 6 qts. per acre per season. Do not use on shelled succulent peas and beans. Edible-pod succulent and dried shelled beans and peas only. REI: 12-hour. PHI: 3-day for fresh legumes, 14-day for dry legumes.

**Warrior II® (lambda-cyhalothrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 7-day for fresh legumes, or 21-day for dry legumes. RUP.

### Thrips

**Admire Pro® (imidacloprid)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 7-10.5 fl. oz. per acre soil application. Do not exceed 1 soil application per season. REI: 12-hour. PHI: 21-day.

**Assail 30SG® (acetamiprid)** Beans (Fresh), Lima Beans, Peas (Fresh), Southern Peas/Cowpeas 4.5-5.3 oz. per acre. Do not exceed 3 applications per season. REI: 12-hour. PHI: 7-day.

**Brigade 2EC® (bifenthrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/

Cowpeas 2.1-6.4 fl. oz. per acre. Treat Mexican Bean Leaf Beetle on dry peas and beans only. Do not exceed 12.8 fl. oz. per acre per season. Allow 3 days between applications on fresh legumes. Allow 7 days between applications on dry legumes. REI: 12-hour. PHI: 3-day for fresh legumes, or 14-day for dry legumes. RUP.

**Entrust SC® (spinosad)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 4.5-6 oz. per acre. Do not exceed 29 oz. per acre per season for succulent legumes, or 12 oz. per acre per season for dry legumes. Do not feed or graze livestock on treated plants. REI: 4-hour. PHI: 3-day for fresh legumes, or 28 day for dry legumes. OMRI-listed.

**Mustang Maxx® (zeta-cypermethrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 2.72-4.0 fl. oz. Do not exceed 24. fl. oz. per acre per season. REI: 12-hour. PHI: 1-day for fresh legumes, or 21-day for dry legumes. RUP.

**Radiant 1SC® (spinetoram)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 5-8 fl. oz. per acre. Do not exceed 28 fl. oz. per acre. per season for succulent legumes, or 12 fl. oz. per acre for dry legumes. REI: 4-hour. PHI: 3-day for fresh legumes, or 28-day for dry legumes.

**Sevin XLR Plus® (carbaryl)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 0.5-1.5 qts. per acre. Do not exceed 6 qts. per acre per season. Do not use on shelled succulent peas and beans. Edible-pod succulent and dried shelled beans and peas only. REI: 12-hour. PHI: 3-day for fresh legumes, 14-day for dry legumes.

**Warrior II® (lambda-cyhalothrin)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. Do not feed or graze livestock on treated plants. REI: 24-hour. PHI: 7-day for fresh legumes, or 21-day for dry legumes. RUP.

### Wireworms

**Cruiser 5FS® (thiamethoxam)** Beans (Dry), Beans (Fresh), Lima Beans, Peas (Dry), Peas (Fresh), Southern Peas/Cowpeas 1.28 fl. oz. per 100 lbs. of seed. Do not apply a neonicotinoid insecticide within 45 days of planting treated seed. REI: 12-hour.

OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.

# Mint

## Peppermint and Spearmint Varieties

**Peppermint:** Black Mitcham, Robert's Mitcham, Todd's Mitcham, and Murray Mitcham. The latter three varieties are more resistant to verticillium wilt.

**Spearmint:** Scotch Spearmint and Native Spearmint. These two spearmints have distinctly different oils.

## Planting and Rotation

Mints are grown from dormant runners (stolons) dug from existing fields in the late fall or spring. Because verticillium wilt disease is an important problem (even with the more resistant varieties), growers should always use disease-free planting stock. Certified and disease-free stocks are available. Also, careful fall plowing of established stands is important for both winter protection and for reducing the incidence of mint rust and other foliar diseases. "Squirrely" mint, which occurs primarily on peppermint, is caused by the mint bud mite, *Tarsonemus pipermosae*.

Although mints are perennials, stands should not be maintained longer than 3 or 4 years in a rotation program. Older stands may show serious build-ups of disease, insect, and weed problems.

Irrigation significantly increases oil yields both on muck and mineral soils, even in seasons with normal rainfall.

## Fertilizing

For established mint, apply 120 to 150 pounds N per acre in split application (before emergence and before canopy closure). Potash and phosphorous should be maintained at 400 pounds K<sub>2</sub>O per acre and 50 pounds P<sub>2</sub>O<sub>5</sub> per acre.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### **Leaf Spot of Mint - Septoria Fungus**

chlorothalonil formulations (chlorothalonil) Bravo<sup>®</sup>, Echo<sup>®</sup>, Equus<sup>®</sup>, and Initiate<sup>®</sup> are labeled at various rates. Indiana only. REI: 12-hour. PHI: 80-day.

#### **Rust of Multiple Crops - Puccinia Fungus**

azoxystrobin formulations (azoxystrobin) 6-15.4 fl. oz. per acre. Quadris<sup>®</sup> and Satori<sup>®</sup> formulations are labeled. REI: 4-hour. PHI: 0-day for fresh; 7-day for processed.

chlorothalonil formulations (chlorothalonil) Bravo<sup>®</sup>, Echo<sup>®</sup>, Equus<sup>®</sup>, and Initiate<sup>®</sup> are labeled at various rates. Indiana only. REI: 12-hour. PHI: 80-day.

#### **Headline SC<sup>®</sup> (pyraclostrobin)** 9-12 fl. oz. per acre.

Additional formulations of Headline may be labeled. REI: 12-hour. PHI: 14-day.

**Propimax EC<sup>®</sup> (propiconazole)** 4 fl. oz. per acre. REI: 12-hour. PHI: 90-day.

**Rally 40WSP<sup>®</sup> (myclobutanil)** 4-5 fl. oz. per acre. REI: 24-hour. PHI: 30-day.

#### **Wilt of Multiple Crops - Verticillium Fungus**

**Crop rotation** Rotate plantings after no more than 3 or 4 years.

**Variety selection** Use wilt resistant varieties of peppermint. Native spearmint is resistant.

## Weed Control

### Recommended Controls

#### **Burndown or Directed/Shielded Application**

#### **Broadleaf and Grass Weeds**

glyphosate formulations (glyphosate) Apply as a spot treatment in a 1-2% solution to actively growing weeds. The sprayed mint crop will be killed. Not all glyphosate formulations are labeled for mint. Apply as a spot treatment to no more than 10% of any acreage but can reapply to the same area at 30-day intervals. Avoid any drift to nontarget crops. REI: 4-hour. PHI: 7-day.

**paraquat formulations (paraquat)** 1.3-2 pt. per acre of 3 lb. per gal. formulations or 2-3 pt. per acre of 2 lb. per gal. formulations. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Apply to dormant mint when weeds are less than 6 in. tall. Do not make more than 2 applications per year or apply more than 2 pt. per dormant season. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 24-hour. RUP.

### **Preemergence Broadleaf and Grass Weeds**

**Command 3ME® (clomazone)** 1.3 pt. per acre. Apply in spring before mint starts to grow. Do not apply to emerged mint. Do not exceed 1 application per season. Some whitening of tissue may occur as mint emerges. REI: 12-hour. PHI: 84-day.

**Devrinol DF-XT® (napropamide)** 8 lb. per acre. *New plantings:* Apply soon after planting. *Established plantings:* Must be established for at least one growing season. REI: 24-hour.

**Prowl H2O® (pendimethalin)** 1.5-4.0 pts. per acre. *Established mint only.* Use low rate on coarse soils. Apply to dormant mint before mint and weeds start to grow. REI: 24-hour. PHI: 90-day.

**trifluralin formulations (trifluralin)** Apply 1.0-1.5 pt. per acre of 4 lb. per gal. trifluralin to established, dormant or semi-dormant mint, late winter to spring or in the fall after harvest prior to emergence of targeted weed species. Must be incorporated mechanically or by 0.5 in. rainfall or irrigation within 3 days of application. REI: 12-hour.

### **Preemergence Broadleaf Weeds**

**Chateau SW® (flumioxazin)** 2-4 oz. per acre. Apply to established, dormant mint from November 25 to March 1. Do not apply to frozen or snow covered ground. Do not exceed 4 oz. per acre in a single application or more than 8 oz. per acre in a single growing season. Do not make a sequential application of Chateau within 60 days of first application. Applying to nondormant mint may result in unacceptable injury. For improved postemergence control, tank-mix with paraquat and add NIS at 0.5 pt. per 25 gal. of solution (0.25% v/v). Adding a nitrogen source will increase activity. REI: 12-hour. PHI: 80-day.

**Goal 2XL® (oxyfluorfen)** *Indiana and Michigan only. Not for use on mineral or black sand soils.* 2-3 qt. per acre Goal 2XL or 1 pt. per acre GoalTender. Use 20-40 gals. of water per acre. Add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v) if emerged weeds are present. Apply to dormant spearmint and peppermint on muck soil (greater than 20% organic matter) before weeds are 4 in. tall. Application to emerged mint will result in severe injury. REI: see label.

**Sinbar WDG® (terbacil)** 1-2 lb. per acre. Apply before mint emerges. Apply in the spring just after the last cultivation. Do not apply more than 2 lb. per acre per season. Discontinue use 1 year before rotating to other crops. REI: 12-hour. PHI: 60-day.

**Spartan 4F® (sulfentrazone)** *New plantings:* Apply 3.3-9.0 fl. oz. per acre after planting before weeds and mint emerge. *Established plantings:* Apply 4.5-12.0 fl. oz. per acre to established mint when it is dormant, in the fall after postharvest cultivation, and/or in the spring after cultivation. *Renovation applications:* Up to 8 fl. oz. per acre can be applied at dormancy followed by up to 4 fl. oz. per acre 1-3 days after the first harvest. Dormant and postharvest applications must be at least 100 days apart. Use lower rates on coarse soils with low organic matter. Rainfall or irrigation is required to move herbicide into the soil. Application may injure crop as mint emerges. Application to emerged mint will result in severe injury. Do not exceed 12 fl. oz. per 12-month period. Do not apply to mint grown on sands with less than 1% organic matter. REI: 12-hour. PHI: 92-day for dormant and new planting applications, 55-day for renovation applications.

### **Postemergence Broadleaf Weeds**

**Aim EC® (carfentrazone)** 0.5 to 1.92 fl. oz. per acre. Apply before crop emergence to emerged weeds less than 4 in. tall. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). REI: 12-hour. PHI: 5-day

**Basagran® (bentazon)** Use 4L formulations at 1-2 pts. per acre and 5L formulations at 1.2-1.6 pt. per acre. Apply after mint and weeds have emerged. To control yellow nutsedge and Canada thistle, repeat application 7-10 days later. COC will enhance activity. Do not exceed 4 pt. per acre per season. REI: 48-hour. PHI: 20-day.

**Moxy 2E® (bromoxynil)** 1.0-1.5 pt. per acre. Apply in at least 10 gal. water per acre. Apply before weeds have more than 4 leaves and only on established mint that has been harvested at least one year prior to application. Do not apply to mint growing under stressful conditions or when air temperatures are, or are expected to be, more than 70°F within 5 days of application. REI: 24-hour. PHI: 70-day.

**Sinbar WDG® (terbacil)** 1.0-1.5 lb. per acre. Apply before mint emerges. Apply to broadleaf weeds less than 2" tall or across and grasses less than 1" tall. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS to 25 gal. of solution (0.25% v/v). Do not apply more than 2 lb. per acre per season. Discontinue use 1 year before rotating to other crops. REI: 12-hour. PHI: 60-day.

**Stinger® (clopyralid)** 0.33-1.0 pt. per acre. Use 4 fl. oz. of NIS per 25 gals. of spray solution. Apply up to 0.5 pt. in spring or up to 1 pt. in fall. Controls mainly composites and nightshade. To control Canada thistle in spring, apply before bud stage. Do not use mint straw, hay, or spent hay for compost or mulch and do not dispose of on land to be rotated to broadleaf crops due to herbicide remaining in mint hay or straw that will injure broadleaf plants. Do not exceed 1 pt. per acre per growing season. REI: 12-hour. PHI: 45-day.

**Thistrol® (MCPB)** 1-2 pts. per acre. Apply in spring after mint emerges to suppress broadleaf weeds, or apply in fall to control winter annuals. May injure mint. Oil yields may be reduced if mint is more than 6 inches tall at the time of application. Bindweed suppression is best with spring application when weeds are 6-8 inches long. REI: 24-hour. PHI: 40-day.

### Postemergence Grass Weeds

**Assure II® (quizalofop)** 8-12 oz. per acre. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Apply to actively growing grass. Do not exceed 2 applications or 24 fl. oz. per acre per season. Applications must be greater than 7 days apart. REI: 12-hour. PHI: 30-day.

**clethodim formulations (clethodim)** Use 2 lb. per gal. formulations at 6-16 fl. oz. per acre with 1 qt. COC per 25 gal. of spray solution (1% v/v). Do not exceed 32 fl. oz. per acre per season. Use 0.97 lb. per gal. formulations at 9-16 fl. oz. per acre to control annual grasses and 12-32 fl. oz. per acre to control perennial grasses. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64

fl. oz. per acre per season. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 21-day.

**Poast® (sethoxydim)** 1.0-2.5 pt. per acre. Add 1 qt. COC per 25 gal. of spray solution (1% v/v). Spray on actively growing grass. Do not exceed 5 pt. per acre per season. REI: 12-hour. PHI: 20-day.

## Insect Control

### Recommended Controls

#### Caterpillars

**Bacillus thuringiensis** formulations for Lepidopterans (*Bacillus thuringiensis aizawai* strain ABTS-1857, *Bacillus thuringiensis aizawai* strain GC-91, *Bacillus thuringiensis kurstaki* strain ABTS-351, *Bacillus thuringiensis kurstaki* strain EVB-113-19, *Bacillus thuringiensis kurstaki* strain SA-11) Various Bt products are available for control of young caterpillars (Agree®, Biobit®, Dipel®, Javelin®, etc.) Different Bt subspecies have different control properties. Check labels for pest insects controlled before use. Follow label directions for rates, timing of application and required safety equipment. REI: 4-hour. PHI: 0-day.

**Avaunt 30WDG® (indoxacarb)** 3.5 oz. per acre. For cutworms, and loopers. Do not exceed 14 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Coragen® (chlorantraniliprole)** 3.5-7.0 fl. oz. per acre. For cutworms, loopers and armyworms. Do not exceed 15.4 fl. oz. per acre season. Allow 14 days between applications. REI: 4-hour. PHI: 3-day.

**Entrust® (spinosad)** 4-10 fl. oz. per acre. For cutworms, loopers and armyworms. Do not exceed 29 fl. oz. per acre per crop. Allow 4 days between applications. REI: 4-hour. PHI: 7-day. OMRI-listed.

**Intrepid 2F® (methoxyfenozide)** 10-16 fl. oz. per acre. For cutworms, loopers and armyworms. Do not exceed 64 fl. oz. per acre per year. REI: 4-hour. PHI: 14-day.

**Lannate LV® (methomyl)** 3 pts. per acre. For cutworms, and loopers. Do not exceed 6 pts. per acre per crop or 4 applications per year. REI: 48-hour. PHI: 14-day. RUP.

**Lorsban Advanced® (chlorpyrifos)** 2-4 pts. per acre. For cutworms. Only 1 application per growing season with max rate of 4 pts. per acre. REI: see label. PHI: 90-day. RUP.

**Orthene 97 Soluble® (acephate)** 1 lb. per acre. For cutworms, and loopers. Do not exceed 2 1/8 lbs. per acre per season or 2 applications per season. Allow 7 days between applications. REI: 24-hour. PHI: 14-day.

**Radiant 1SC® (spinetoram)** 4-12 fl. oz. per acre. For cutworms, loopers and armyworms. Do not exceed 39 fl. oz. per acre per season or 4 applications per season. Allow 4 days between treatments. REI: 4-hour. PHI: 7-day.

### **Cutworm Caterpillars**

**Lorsban Advanced® (chlorpyrifos)** 2-4 pts. per acre. Use lower rate when cutworm larvae are less than 0.75 inch long. Only 1 application per growing season with max rate of 4 pts. per acre. REI: see label. PHI: 90-day. *RUP*.

### **Flea Beetles**

**Actara® (thiamethoxam)** 1.5-3.0 oz. per acre. Do not exceed 12 oz. per acre per season. Must wait at least 14 days between treatments. See pollinator precautions. REI: 12-hour. PHI: 7-day.

**Lannate LV® (methomyl)** 2.25-3 pts. per acre. For best results, apply immediately after harvest on stubble. Do not exceed 4 applications per crop and 6 pts. per acre per crop. REI: 48-hour. PHI: 14-day. *RUP*.

**Malathion 5EC® (malathion)** 1.5 pts. per acre. For best results, apply immediately after harvest on stubble. REI: see label. PHI: 7-day.

### **Mites**

**Acramite 50WS® (bifenazate)** 0.75-1.5 lbs. per acre. Do not exceed 1 application per season. REI: 12-hour. PHI: 7-day.

**Agri-Mek 0.15EC® (abamectin)** 8-12 fl. oz. per acre. Do not exceed 36 fl. oz. per acre per season. REI: 12-hour. PHI: 28-day. *RUP*.

**Dicofol 4E (dicofol)®** 1.75-2.5 pts. per acre. Do not exceed 1 application per season. REI: 32-day. PHI: 30-day.

**Portal® (fenpyroximate)** 1-2 pts. per acre. Do not exceed 2 applications per season. Allow 7 days between applications. REI: 12-hour. PHI: 7-day.

**Zeal® (etoxazole)** 2-4 oz. per acre. Do not exceed 1 application per season. REI: 12-hour. PHI: 7-day.

# Okra

## Planting and Spacing

Seed 12 to 18 inches apart in rows 36 inches apart. Seed only after the soil has warmed to 65°F to 70°F for several days. Black plastic mulch with drip irrigation will increase yields. Transplants can be used for early production.

## Fertilizing

**Lime:** To maintain a soil pH of 6.0 to 6.5. Okra is very sensitive to low pH soils.

**Preplant:** N: 40 pounds N per acre preplant broadcast and disked in prior to seeding.  $P_2O_5$ : 0 to 200 pounds per acre.  $K_2O$ : 0 to 300 pounds per acre. Adjust according to soil type, previous management, and soil test results.

**Sidedress N:** Apply 40 pounds N as a sidedress after the first harvest.

## Harvest

Okra should be harvested every 2 to 3 days to maintain optimal market size (2- to 4-inch long pods). Frequent harvesting increases overall yield since the plant will reset pods faster. Okra will yield 8,000 to 10,000 pounds per acre. Okra can be stored at 45°F to 55°F and 90 percent to 95 percent relative humidity for 7 to 10 days.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### ***Wilt of Multiple Crops - Fusarium Fungus***

**Crop rotation** Rotations of several years may reduce Fusarium wilt severity. Avoid fields with Fusarium wilt.

## Weed Control

Weeds in okra can be managed with cultivation and hand-weeding, plastic or other mulches, and herbicides. Because okra is a warm-season, transplanted crop, there should be enough time in the spring to prepare a stale seedbed before planting, which should reduce weed pressure in the crop. Herbicide choices are limited, and the products that can be broadcast do not control many broadleaf weeds, so it is important to include mechanical control in the weed management plan.

### Recommended Controls

#### ***Burndown or Directed/Shielded Applications***

##### ***Broadleaf and Grass Weeds***

glyphosate formulations (glyphosate) 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal) at 0.66-3.3 qts. per acre. Broadcast at least 3 days before transplanting, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. Remove herbicide residue from plastic mulch prior to transplanting. REI 4-hour. PHI: 14-day.

#### ***Burndown or Directed/Shielded Applications***

##### ***Broadleaf Weeds***

**Aim EC® (carfentrazone)** 0.5-2 fl. oz. per acre. Apply prior to transplanting or apply between crop rows with hooded sprayer. Do not apply before direct seeding. Do not allow spray to contact crop. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour.

##### ***Preemergence Broadleaf and Grass Weeds***

**Caparol 4L® (prometryn)** 3 pts. per acre. Apply after seeding before crop emergence. Or apply 1.5 pts. per acre after seeding before crop emergence and apply 1.5 pts. per acre as a post-directed spray when okra has 7-9 leaves and weeds are less than 2 inches tall. Do not exceed 3 pts. per acre per year. REI: 12-hour. PHI: 14-day.

**Dual Magnum® (s-metolachlor)** 1-2 pts. per acre. Indiana, Michigan, and Ohio only. Apply to okra at least 4 inches tall before weeds emerge. Direct the spray to minimize contact with crop foliage, or apply only between crop rows. Do not incorporate. Do not exceed 2 pts. per acre or 1 application per crop per season. REI: 24-hour. PHI: 60-day.

**trifluralin formulations (trifluralin)** 0.5-1 lb. a.i. per acre. Use 4EC formulations at 1-2 pts. per acre. Use 10G formulations at 5-10 lbs. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate before transplanting. Not effective on muck or high organic matter soils. REI: 12-hour.

### **Preemergence Broadleaf Weeds**

**Callisto® (mesotrione)** 6 fl. oz. per acre. Band to row middles prior to weed emergence. Leave 1 foot over row or 6 inches on each side of row unsprayed. Do not apply directly over the planted okra row or severe injury may occur. Injury risk is greatest on coarse-textured soils (sand, sandy loam, or loamy sands). A postemergence hooded application can be made at 3 oz. per acre when okra is at least 3 inches tall at time of application. Add 0.25% NIS v/v to spray solution. Avoid any contact with okra plant foliage. Do not exceed 1 application and 6 oz. per acre per year. REI: 12-hour. PHI: 28-day.

**Sandea® (halosulfuron)** 0.5-1 oz. per acre. Apply between rows of direct-seeded or transplanted crop. Use lower rates on coarse soils with low organic matter. Add 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Avoid contact of the herbicide with the crop. Avoid contact with surface of plastic mulch if present. Effective against nutsedge. Do not exceed 2 oz. per acre per 12-month period. REI: 12-hour. PHI: 30-day.

### **Postemergence Broadleaf and Grass Weeds**

**Glyphosate products.** See details above for Burndown or Directed/Shielded Applications.

### **Postemergence Broadleaf Weeds**

**Aim EC® (carfentrazone)** See details above for Burndown or Directed/Shielded Applications Broadleaf Weeds.

**Sandea® (halosulfuron)** See details above for Preemergence Broadleaf Weeds.

### **Postemergence Grass Weeds**

**Poast® (sethoxydim)** 1-1.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5.5 pts. per acre per season. REI: 12-hour. PHI: 14-day.

## **Insect Control**

### **Recommended Controls**

#### **Aphids**

**Admire Pro® (imidacloprid)** 1.3-2.2 fl. oz. per acre foliar application, 7-14 fl. oz. per acre soil application. Do not exceed 6.7 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day for foliar applications, 21-day for soil applications.

**Assail 30SG® (acetamiprid)** 2-4 oz. per acre. REI: 12-hour. PHI: 7-day.

**Beleaf 50SG® (flicnicamid)** 2.8-4.28 oz. per acre. REI: 12-hour. PHI: 0-day.

**Malathion 5EC® (malathion)** 1.5 pts. per acre. REI: see label. PHI: 1-day.

**Movento® (spirotetramat)** 4-5 fl. oz. per acre. REI: 24-hour. PHI: 1-day.

**Sivanto Prime® (flupyradifurone)** 7-14 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

#### **Corn Earworm/Fruitworm Caterpillar**

**Bacillus thuringiensis** formulations for Lepidopterans

(*Bacillus thuringiensis aizawai* strain ABTS-1857, *Bacillus thuringiensis aizawai* strain GC-91, *Bacillus thuringiensis kurstaki* strain ABTS-351, *Bacillus thuringiensis kurstaki* strain EVB-113-19, *Bacillus thuringiensis kurstaki* strain SA-11)

See label. Different Bt subspecies may have different insect control properties. Check labels for pest insects controlled before use. Follow label directions for rates, timing of application and required safety equipment. REI: 4-hour. PHI: See label.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**Coragen® (chlorantraniliprole)** 3.5-7.5 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

**Entrust SC® (spinosad)** 3-6 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day. OMRI-listed.

**Exirel® (cyantraniliprole)** 7-13.5 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Harvanta® (cyclaniliprole)** 20.9-26.4 fl. oz. per acre. Use with adjuvant. Do not exceed 65.6 fl. oz. per acre per season. Allow 5 days between treatments. REI: 4-hour. PHI: 1-day.

**Radiant 1SC® (spinetoram)** 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Sevin XLR Plus® (carbaryl)** 1.0-1.5 qts. per acre. Do not exceed 6 qts. per acre per season. REI: 12-hour. PHI: 3-day.

### ***Japanese Beetle***

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**EverGreen Pro 60-6® (piperonyl butoxide, pyrethrins)**  
2-12.6 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Malathion 5EC® (malathion)** 1.9 pts. per acre. REI: see label. PHI: 1-day.

### ***Mites***

**Acramite 50WS® (bifenazate)** 0.75-1.0 lb. per acre. Do not exceed 1 application per season. REI: 12-hour. PHI: 3-day.

**Zeal® (etoxazole)** 2-3 oz. per acre. Do not exceed 1 application per season. REI: 12-hour. PHI: 7-day.

### ***Stink Bugs***

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Sevin XLR Plus® (carbaryl)** 1.0-1.5 qts. per acre. Do not exceed 6 qts. per acre per season. REI: 12-hour. PHI: 3-day.

# Dry Bulb and Green Bunching Onion, Garlic, and Leek

## Spacing

**Onion:** Raised beds with two double rows or wide rows spaced 14 inches apart on top of the bed with 12 seeds per foot within the wide (2 inches) row. Seed: 4 pounds per acre. Or transplant 4 inches apart in rows.

**Garlic:** Rows 12 to 36 inches apart with cloves 3 to 6 inches apart in the row. Plant bulbs 3 to 4 inches deep, with top of clove twice the depth of the clove height. For mechanical cultivation, plant flat side of clove perpendicular to the length of the row; for hand cultivation in dense plantings, plant angled side of clove parallel to the length of the row. Plant in fall 6 to 8 weeks before ground freezes.

**Leek:** Rows 14 to 18 inches apart with transplants 3 to 4 inches apart in the row.

## Fertilizing

### Onion, Garlic and Leek

**Lime:** Mineral soils: to maintain a soil pH of 6.0 to 6.8. Organic soils: lime if pH is less than 5.2.

## Harvesting

**Green onion:** Harvest by pulling from soil after bulb base is thicker than a pencil but before bulbing. Optional undercutting can be used to make pulling easier. Remove dirty outer layer from bulb area. Trip roots. Trim tops as needed if allowed by state regulations. Green onions are usually sold in bunches. Harvest knob onions by pulling from soil when bulb has reached desired stage of development. Follow practices for green onions.

**Dry bulb onion:** Harvest dry bulb onions after tops have naturally fallen over. If a sprout inhibitor is used on storage onions, time application according to label instructions. Undercutting several days before harvest can improve keeping quality of storage onions. Dig from soil and dry in field or indoors at 75°F to 80°F and 70 percent to 80 percent relative humidity. Cut tops about 1 inch from bulb at harvest or after drying, or braid tops and hang onions to dry. Clean dry onions by gently brushing.

**Leek:** Harvest when stalk is 1 inch or more in diameter. Undercut plants, pull from soil, trim, and bunch.

**Garlic:** Harvest when tops have fallen over and partially dried. Lift from soil and dry protected from sun and rain. After drying, trim roots and remove tops, or leave tops on for braiding.

## Onion and Leek

**Preplant:** N: for mineral soils, 70 pounds N per acre broadcast or applied to bed before planting for transplanted crops, or half broadcast preplant and half applied as a band 2 inches below the seed for direct seeded crops; for organic soils, 100 pounds N per acre broadcast and disked in.  $P_2O_5$ : 25 to 250 pounds per acre.  $K_2O$ : 0 to 250 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. At seeding, spray directly on the seed a solution of 2-6-0 at 1 pint per 100 feet of linear row. A 2-6-0 solution is equivalent to a 1:5 dilution of 10-34-0 liquid fertilizer with water. On muck soils with a pH greater than 6.0, add 1 pound of  $MnSO_4$  per 1,000 feet of row at seeding, or use foliar Mn at the rate of 0.3 pound/100 gallons. Apply 2 to 3 times during the season starting 3 weeks after emergence.

**Sidedress N:** Mineral soils: 60 pounds N per acre to either side of the row at the 4- to 5-week stage of growth or by June 1. Muck soils: No sidedress N needed unless heavy rain occurs.

## Garlic

N: 70 to 125 pounds N per acre total. Adjust according to soil organic matter content and cropping history. Broadcast and incorporate 0 to 20 pounds N per acre before planting in the fall. Apply half the remainder when garlic begins to grow in the spring, and the rest in 1 to 2 sidedressings at 3-week intervals, ending 4 to 6 weeks before harvest.  $P_2O_5$ , 25 to 250 pounds per acre.  $K_2O$ : 0 to 250 pounds per acre. Adjust according to soil type, previous management and soil test results for your state. Broadcast and incorporate before planting in the fall.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### **Basal Rot of Alliums - Fusarium Fungus**

Managing soilborne insect pests may reduce disease incidence.

**Crop rotation** *Garlic, Leek, Onion (Dry), Onion (Green)*  
Crop rotations of longer than four years can help reduce disease.

**Variety selection** *Garlic, Leek, Onion (Dry), Onion (Green)* Use resistant varieties.

#### **Bulb Rot of Alliums - Pseudomonas Bacteria**

**ManKocide® (copper hydroxide, mancozeb)** *Garlic, Onion (Dry)* 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day.

#### **Center Rot of Alliums - Pantoea Bacteria**

Use pathogen-free seed. Rotate out of *Allium* species. Avoid overhead irrigation that might spread these diseases. Over-fertilizing with nitrogen can make the crop more susceptible. Avoid injuring bulbs and cut only when tops are dry.

Applying fixed copper products may reduce the spread of these diseases. For emerged annuals, apply before planting or crop emergence. Products labeled for bacterial leaf blight may be helpful for other bacterial diseases, including bacterial flower stalk and leaf necrosis caused by *Pantoea agglomerans*.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Garlic, Leek, Onion (Dry), Onion (Green)*  
Several copper products are labeled at various rates. REI: see label. PHI: 0-day.

**ManKocide® (copper hydroxide, mancozeb)** *Garlic, Onion (Dry)* 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day.

#### **Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens**

Use healthy, disease-free seed *Garlic, Leek, Onion (Dry), Onion (Green)* Use pathogen free sets and seed.

**azoxystrobin formulations (azoxystrobin)** *Garlic, Leek, Onion (Dry), Onion (Green)* 0.4-0.8 fl. oz. per 1,000 row-feet. Formulations include Quadris® flowable and Satori®. Apply pre-plant or at-plant. REI: 4-hour. PHI: 0-day.

**Ridomil Gold SL® (mefenoxam)** *Garlic, Leek, Onion (Dry), Onion (Green)* 0.5-1.0 pts. per acre. REI: 48-hour. PHI: 0-day.

**Ultra Flourish® (mefenoxam)** *Garlic, Leek, Onion (Dry), Onion (Green)* 1-2 pts. per acre. REI: 48-hour. PHI: 0-day.

**Uniform® (mefenoxam, azoxystrobin)** *Garlic, Leek, Onion (Dry), Onion (Green)* 0.34 fl. oz. per 1,000 ft. of row. Make one application per crop season. REI: 0-hour. PHI: 0-day.

#### **Downy Mildew of Multiple Crops - Peronospora Oomycete**

Use pathogen-free sets and seed. Plant in areas with adequate drainage and air movement to reduce leaf wetness and humidity. Destroy cull piles and debris. Avoid excess nitrogen applications and overhead irrigation. Use a three-year rotation where the disease is known to be a problem. Cool, wet conditions favor the development of this disease.

**Use healthy, disease-free seed** *Garlic, Leek, Onion (Dry), Onion (Green)*

**Ariston® (chlorothalonil, cymoxanil)** *Garlic, Onion (Dry)* 1.6-2.4 pts. per acre. REI: 12-hour. PHI: 7-day.

**Ariston® (chlorothalonil, cymoxanil)** *Leek, Onion (Green)* 2-2.4 pts. per acre. REI: 12-hour. PHI: 14-day.

**Catamaran® (potassium phosphite, chlorothalonil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 4-7 pts. per acre. REI: 12-hour. PHI: 7-day for dry bulb and garlic; 14-day for green bunching and leek.

**Dexter Max® (mancozeb, azoxystrobin)** *Onion (Dry)* 3.2 lb. per acre. REI: 24-hour. PHI: 7-day.

**Dexter Xcel® (mancozeb, azoxystrobin, tebuconazole)** *Onion (Dry)* 56-72 fl. oz. per acre. REI: See label. PHI: 7-day.

**Forum 4.18SC® (dimethomorph)** *Garlic, Leek, Onion (Dry), Onion (Green)* 6 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Gavel 75DF® (zoxamide, mancozeb)** *Garlic, Onion (Dry)* 1.5-2 lbs. per acre. REI: 48-hour. PHI: 7-day.

**mancozeb formulations (mancozeb)** *Garlic, Onion (Dry)* Dithane®, Elixer®, Manzate®, Penncozeb®, and Roper® are labeled at various rates for dry bulb onion and garlic. REI: 24-hour. PHI: 7-day.

**Omega 500F® (fluazinam)** *Garlic, Onion (Dry)* 1 pt. per acre. REI: see label. PHI: 7-day.

**Orondis Opti Premix® (oxathiapiprolin, chlorothalonil) Garlic, Leek, Onion (Dry), Onion (Green)** See label. Orondis Opti® premix. Not for use in New York. REI: 12-hour. PHI: 7-day for dry bulb onions and garlic. 14-day for green onions, leeks, and shallots.

**Orondis Ultra Premix® (oxathiapiprolin, mandipropamid) Garlic, Leek, Onion (Dry), Onion (Green)** See label. Orondis Ultra premix. Not for use in New York. REI: 4-hour. PHI: 7-day for dry bulb onions and garlic. 14-day for green onions, leeks, and shallots.

**Reason 500SC® (fenamidone) Garlic, Leek, Onion (Dry), Onion (Green)** 5.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Revus® (mandipropamid) Garlic, Leek, Onion (Dry), Onion (Green)** 8 fl. oz. per acre. REI: 4-hour. PHI: 7-day.

**Ridomil Gold Bravo SC® (mefenoxam, chlorothalonil) Garlic, Leek, Onion (Dry), Onion (Green)** 2.5 pts. per acre. REI: 48-hour. PHI: 7-day for dry bulb and garlic; 14-day for green bunching and leek.

**Ridomil Gold Copper® (mefenoxam, copper hydroxide) Garlic, Leek, Onion (Dry), Onion (Green)** 2 lbs. per acre. REI: 48-hour. PHI: 7-day for green bunching and leeks; 10-day for dry bulb and garlic.

**Ridomil Gold MZ WG® (mefenoxam, mancozeb) Garlic, Leek, Onion (Dry), Onion (Green)** 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day.

**Viathon® (potassium phosphite, tebuconazole) Garlic, Leek, Onion (Dry), Onion (Green)** 2-3 pts. per acre. REI: 12-hour. PHI: 7-day.

**Zampro® (ametoctradin, dimethomorph) Garlic, Leek, Onion (Dry), Onion (Green)** 14 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Zing!® (zoxamide, chlorothalonil) Garlic, Leek, Onion (Dry), Onion (Green)** 30 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

### **Leaf Blight and Stalk Rot of Onions -**

#### **Stemphylium Fungus**

Stemphylium causes leaf blight and stalk rot but rarely affects the bulb. Long warm periods with leaf wetness favor disease development.

**Aprovia Top® (difenoconazole, benzovindiflupyr (soltatenol)) Onion (Dry), Onion (Green)** 10.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Cabrio EG® (pyraclostrobin) Garlic, Leek, Onion (Dry), Onion (Green)** 8-12 oz. per acre. REI: 12-hour. PHI: 7-day.

**Fontelis® (penthiopyrad) Garlic, Leek, Onion (Dry), Onion (Green)** 16-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**Inspire Super® (difenoconazole, cyprodinil) Garlic, Leek, Onion (Dry), Onion (Green)** 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day for dry bulb and garlic; 14-day for green bunching onion and leek.

**Luna Experience® (fluopyram, tebuconazole) Garlic, Leek, Onion (Dry), Onion (Green)** 12.8 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Luna Tranquility® (fluopyram, pyrimethanil) Garlic, Leek, Onion (Dry), Onion (Green)** 16-27 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Merivon® (fluxapyroxad, pyraclostrobin) Garlic, Leek, Onion (Dry), Onion (Green)** 5.5-11 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Pristine 38WG® (boscalid, pyraclostrobin) Garlic, Leek, Onion (Dry), Onion (Green)** 10.5-18.5 oz. per acre. REI: 12-hour. PHI: 7-day.

**Quadris Top® (azoxystrobin, difenoconazole) Garlic, Leek, Onion (Dry), Onion (Green)** 12-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Switch 62.5WG® (cyprodinil, fludioxonil) Garlic, Leek, Onion (Dry), Onion (Green)** 11-14 oz. per acre. REI: 12-hour. PHI: 7-day.

#### **Leaf Blight of Alliums - Botrytis Fungus**

Reduce leaf wetness by ensuring adequate drainage, by spacing plants to promote air movement, and by using overhead irrigation sparingly.

**Crop rotation Onion (Dry), Onion (Green)** Practice 3-4 year crop rotation. Rotation out of onions or related vegetables reduces the threat of these diseases in future onion crops.

**Sanitation Onion (Dry), Onion (Green)** Destroy cull piles.

**Ariston® (chlorothalonil, cymoxanil) Garlic, Onion (Dry)** 1.6-2.4 pts. per acre. REI: 12-hour. PHI: 7-day.

**Ariston® (chlorothalonil, cymoxanil) Leek, Onion (Green)** 2-2.4 pts. per acre. REI: 12-hour. PHI: 14-day.

**azoxystrobin formulations (azoxystrobin) Garlic, Leek, Onion (Dry), Onion (Green)** 9-15.5 fl. oz. per acre. Formulation include Quadris® and Satori®. REI: 4-hour. PHI: 0-day.

**Cabrio EG® (pyraclostrobin)** *Garlic, Leek, Onion (Dry), Onion (Green)* 12 oz. per acre. Suppression only. REI: 12-hour. PHI: 7-day.

**chlorothalonil formulations (chlorothalonil)** *Garlic, Leek, Onion (Dry), Onion (Green)* Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. Suppression only for downy mildew. REI: 12-hour. PHI: 7-day for dry bulb and garlic; 14-day for green bunching and leek.

**Custodia (azoxystrobin, tebuconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 12.9 fl. oz. per acre. Suppression only. REI: 12-hour. PHI: 7-day.

**Dexter Max® (mancozeb, azoxystrobin)** *Onion (Dry)* 3.2 lb. per acre. REI: 24-hour. PHI: 7-day.

**Dexter Xcel® (mancozeb, azoxystrobin, tebuconazole)** *Onion (Dry)* 56-72 fl. oz. per acre. REI: See label. PHI: 7-day.

**Endura® (boscalid)** *Garlic, Leek, Onion (Dry), Onion (Green)* 6.8 oz. per acre. REI: 12-hour. PHI: 7-day.

**Fontelis® (penthiopyrad)** *Garlic, Leek, Onion (Dry), Onion (Green)* 16-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**Inspire Super® (difenoconazole, cyprodinil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day for dry bulb and garlic; 14-day for green bunching onion and leek.

**iprodione formulations (iprodione)** *Onion (Dry)* Iprodione 4L AG®, Meteor®, Rovral 4 Flowable®. REI: 24-hour. PHI: 14-day.

**Luna Experience® (fluopyram, tebuconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 8-12.8 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Luna Tranquility® (fluopyram, pyrimethanil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 16-27 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**mancozeb formulations (mancozeb)** *Garlic, Onion (Dry)* Dithane®, Elixer®, Manzate®, Penncozeb®, and Roper® are labeled at various rates for dry bulb onion and garlic. REI: 24-hour. PHI: 7-day.

**Merivon® (fluxapyroxad, pyraclostrobin)** *Garlic, Leek, Onion (Dry), Onion (Green)* 8-11 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Omega 500F® (fluazinam)** *Garlic, Onion (Dry)* 1 pt. per acre. REI: see label. PHI: 7-day.

**Pristine 38WG® (boscalid, pyraclostrobin)** *Garlic, Leek, Onion (Dry), Onion (Green)* 14.5-18.5 oz. per acre. REI: 12-hour. PHI: 7-day.

**propiconazole formulations (propiconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* See label. Propimax EC® and Tilt® are labeled. REI: 12-hour. PHI: See label.

**Quadris Opti® (azoxystrobin, chlorothalonil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 1.6-3.2 pts. per acre. REI: 12-hour. PHI: 7-day for dry bulb and garlic; 14-day for green bunching and leeks.

**Quadris Top® (azoxystrobin, difenoconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 12-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Quilt Xcel® (azoxystrobin, propiconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 17.5-26 fl. oz. per acre. REI: 12-hour. PHI: 0-day for leek and green onion; 14-day for dry bulb and garlic.

**Scala SC® (pyrimethanil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 18 fl. oz. per acre. See label for tank mix instructions. REI: 12-hour. PHI: 7-day.

**Switch 62.5WG® (cyprodinil, fludioxonil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 11-14 oz. per acre. REI: 12-hour. PHI: 7-day.

**Vanguard WG® (cyprodinil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 10 oz. per acre. REI: 12-hour. PHI: 7-day.

### **Leaf Blight of Alliums - *Pantoea Bacteria***

Use pathogen-free seed. Rotate out of *Allium* species. Avoid overhead irrigation that might spread these diseases. Over-fertilizing with nitrogen can make the crop more susceptible. Avoid injuring bulbs and cut only when tops are dry.

Applying fixed copper products may reduce the spread of these diseases. For emerged annuals, apply before planting or crop emergence. Products labeled for bacterial leaf blight may be helpful for other bacterial diseases, including bacterial flower stalk and leaf necrosis caused by *Pantoea agglomerans*.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Garlic, Leek, Onion (Dry), Onion (Green)* Several copper products are labeled at various rates. REI: see label. PHI: 0-day.

**ManKocide® (copper hydroxide, mancozeb)** *Garlic, Onion (Dry)* 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day.

**Leaf Blight of Alliums - *Xanthomonas* Bacteria**

Use pathogen-free seed. Rotate out of *Allium* species. Avoid overhead irrigation that might spread these diseases. Over-fertilizing with nitrogen can make the crop more susceptible. Avoid injuring bulbs and cut only when tops are dry.

Applying fixed copper products may reduce the spread of these diseases. For emerged annuals, apply before planting or crop emergence. Products labeled for bacterial leaf blight may be helpful for other bacterial diseases, including bacterial flower stalk and leaf necrosis caused by *Pantoea agglomerans*.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) Garlic, Leek, Onion (Dry), Onion (Green)**  
Several copper products are labeled at various rates. REI: see label. PHI: 0-day.

**ManKocide® (copper hydroxide, mancozeb) Garlic, Onion (Dry)** 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day.

**Leaf Spot of Brassicas - *Alternaria* Fungus**

**Sanitation** Onion (Dry), Onion (Green) Destroy cull piles.

**Leaf Streak of Alliums - *Pseudomonas* Bacteria**

Use pathogen-free seed. Rotate out of *Allium* species. Avoid overhead irrigation that might spread these diseases. Over-fertilizing with nitrogen can make the crop more susceptible. Avoid injuring bulbs and cut only when tops are dry.

Applying fixed copper products may reduce the spread of these diseases. For emerged annuals, apply before planting or crop emergence. Products labeled for bacterial leaf blight may be helpful for other bacterial diseases, including bacterial flower stalk and leaf necrosis caused by *Pantoea agglomerans*.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide) Garlic, Leek, Onion (Dry), Onion (Green)**  
Several copper products are labeled at various rates. REI: see label. PHI: 0-day.

**ManKocide® (copper hydroxide, mancozeb) Garlic, Onion (Dry)** 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day.

**Neck Rot of Alliums - *Botrytis* Fungus**

Rotate out of onion for 3 years, avoid injuring plants during handling and storage, destroy onion cull piles and debris, and avoid late-season fertilizer applications. Windrow plants until neck tissues are dry before topping and storage. Cure rapidly and properly. Artificial drying may be necessary (forced heated air at 93-95°F for 5 days). Treatments for *Botrytis* leaf blight may retard or prevent symptomless spread of *Botrytis* neck rot in the field prior to harvest.

**Crop rotation** Garlic, Leek, Onion (Dry), Onion (Green)  
Rotate out of onions for 3 years.

**chlorothalonil formulations (chlorothalonil) Garlic, Onion (Dry)** Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. Suppression only.  
REI: 12-hour. PHI: 7-day.

**Dexter Max® (mancozeb, azoxystrobin) Onion (Dry)** 3.2 lb. per acre. REI: 24-hour. PHI: 7-day.

**Dexter Xcel® (mancozeb, azoxystrobin, tebuconazole) Onion (Dry)** 48-72 fl. oz. per acre. REI: See label.  
PHI: 7-day.

**Fontelis® (penthiopyrad) Garlic, Leek, Onion (Dry), Onion (Green)** 16-24 fl. oz. per acre. REI: 12-hour.  
PHI: 3-day.

**iprodione formulations (iprodione) Onion (Dry)**  
Iprodione 4L AG®, Meteor®, Rovral 4 Flowable®. REI: 24-hour. PHI: 14-day.

**Luna Experience® (fluopyram, tebuconazole) Garlic, Leek, Onion (Dry), Onion (Green)** 8-12.8 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Luna Tranquility® (fluopyram, pyrimethanil) Garlic, Leek, Onion (Dry), Onion (Green)** 16-27 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**mancozeb formulations (mancozeb) Garlic, Onion (Dry)** Dithane®, Elixer®, Manzate®, Penncozeb®, and Roper® are labeled at various rates for dry bulb onion and garlic. REI: 24-hour. PHI: 7-day.

**Merivon® (fluxapyroxad, pyraclostrobin) Garlic, Leek, Onion (Dry), Onion (Green)** 8-11 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Omega 500F® (fluazinam) Garlic, Onion (Dry)** 1 pt. per acre. REI: see label. PHI: 7-day.

**Pristine 38WG® (boscalid, pyraclostrobin) Garlic, Leek, Onion (Dry), Onion (Green)** 14.5-18.5 oz. per acre.  
REI: 12-hour. PHI: 7-day.

**Quadris Opti® (azoxystrobin, chlorothalonil) Garlic, Leek, Onion (Dry), Onion (Green)** 1.6-3.2 pts. per acre. REI: 12-hour. PHI: 7-day for dry bulb and garlic; 14-day for green bunching and leeks.

**Scala SC® (pyrimethanil) Garlic, Leek, Onion (Dry), Onion (Green)** 18 fl. oz. per acre. See label for tank mix instructions. REI: 12-hour. PHI: 7-day.

**Switch 62.5WG® (cyprodinil, fludioxonil) Garlic, Leek, Onion (Dry), Onion (Green)** 11-14 oz. per acre. REI: 12-hour. PHI: 7-day.

**Vanguard WG® (cyprodinil) Garlic, Leek, Onion (Dry), Onion (Green)** 10 oz. per acre. REI: 12-hour. PHI: 7-day.

### **Pink Root of Alliums - Phoma Fungus**

Plants infected with pink root may appear to be nutrient deficient or drought-stressed and stunted. Affected plants have fewer leaves and begin to form bulbs early. The pathogen can survive in soil as deep as 17.7 inches. Temperatures at 75-82°F favor disease development. The pathogen can spread by onion sets and in infested soil carried by machinery, dust storms, and surface run-off.

**Fontelis (pentiopyrad) Onion (Dry)** 24 fl. oz. per acre. Michigan only-applicators must possess Section 2 (ee) label. Use as a broadcast or band spray over the seed bed. See label for details. REI: 12-hour. PHI: 3-day.

### **Purple Blotch of Alliums - Alternaria Fungus**

**Crop rotation** Onion (Dry), Onion (Green) Practice 3-4 year crop rotation. Rotation out of onions or related vegetables reduces the threat of these diseases in future onion crops.

**Aprovia Top® (difenoconazole, benzovindiflupyr (solanenol)) Onion (Dry), Onion (Green)** 10.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Ariston® (chlorothalonil, cymoxanil) Garlic, Onion (Dry)** 1.6-2.4 pts. per acre. REI: 12-hour. PHI: 7-day.

**Ariston® (chlorothalonil, cymoxanil) Leek, Onion (Green)** 2-2.4 pts. per acre. REI: 12-hour. PHI: 14-day.

**azoxystrobin formulations (azoxystrobin) Garlic, Leek, Onion (Dry), Onion (Green)** 6-12 fl. oz. per acre. Formulations include Quadris® and Satori®. REI: 4-hour. PHI: 0-day.

**Cabrio EG® (pyraclostrobin) Garlic, Leek, Onion (Dry), Onion (Green)** 8-12 oz. per acre. REI: 12-hour. PHI: 7-day.

**chlorothalonil formulations (chlorothalonil) Garlic, Leek, Onion (Dry), Onion (Green)** Bravo®, Echo®, Equus®, and Initiate are labeled for use at various rates. Suppression only for downy mildew. REI: 12-hour. PHI: 7-day for dry bulb and garlic; 14-day for green bunching and leek.

**Custodia® (azoxystrobin, tebuconazole) Garlic, Leek, Onion (Dry), Onion (Green)** 6-12.9 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Dexter Max® (mancozeb, azoxystrobin) Onion (Dry)** 3.2 lb. per acre. REI: 24-hour. PHI: 7-day.

**Dexter Xcel® (mancozeb, azoxystrobin, tebuconazole) Onion (Dry)** 48-72 fl. oz. per acre. REI: See label. PHI: 7-day.

**Endura® (boscalid) Garlic, Leek, Onion (Dry), Onion (Green)** 6.8 oz. per acre. REI: 12-hour. PHI: 7-day.

**Fontelis® (pentiopyrad) Garlic, Leek, Onion (Dry), Onion (Green)** 16-24 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**Inspire Super® (difenoconazole, cyprodinil) Garlic, Leek, Onion (Dry), Onion (Green)** 16-20 fl. oz. per acre. REI: 12-hour. PHI: 7-day for dry bulb and garlic; 14-day for green bunching onion and leek.

**iprodione formulations (iprodione) Onion (Dry)** Iprodione 4L AG®, Meteor®, Rovral 4 Flowable®. REI: 24-hour. PHI: 14-day.

**Luna Experience® (fluopyram, tebuconazole) Garlic, Leek, Onion (Dry), Onion (Green)** 8-12.8 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Luna Tranquility® (fluopyram, pyrimethanil) Garlic, Leek, Onion (Dry), Onion (Green)** 16-27 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**mancozeb formulations (mancozeb) Garlic, Onion (Dry)** Dithane®, Elixer®, Manzate®, Penncozeb®, and Roper® are labeled at various rates for dry bulb onion and garlic. REI: 24-hour. PHI: 7-day.

**Merivon® (fluxapyroxad, pyraclostrobin) Garlic, Leek, Onion (Dry), Onion (Green)** 5.5-11 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Muscle ADV® (chlorothalonil, tebuconazole) Garlic, Onion (Dry)** 1.1-1.6 pts. per acre. REI: 12-hour. PHI: 7-day.

**Omega 500F® (fluazinam) Garlic, Onion (Dry)** 1 pt. per acre. REI: see label. PHI: 7-day.

**Pristine 38WG® (boscalid, pyraclostrobin) Garlic, Leek, Onion (Dry), Onion (Green)** 10.5-18.5 oz. per acre. REI: 12-hour. PHI: 7-day.

**propiconazole formulations (propiconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* See label. Propimax EC® and Tilt® are labeled. REI: 12-hour. PHI: See label.

**Quadris Opti® (azoxystrobin, chlorothalonil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 1.6-3.2 pts. per acre. REI: 12-hour. PHI: 7-day for dry bulb and garlic; 14-day for green bunching and leeks.

**Quadris Top® (azoxystrobin, difenoconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 12-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Quilt® (azoxystrobin, propiconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 14-27.5 fl. oz. per acre. REI: 12-hour. PHI: 0-day for green onion; 14-day for dry bulb.

**Quilt Xcel® (azoxystrobin, propiconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 14-21 fl. oz. per acre. REI: 12-hour. PHI: 0-day for leek and green onion; 14-day for dry bulb and garlic.

**Scala SC® (pyrimethanil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 18 fl. oz. per acre. See label for tank mix instructions. REI: 12-hour. PHI: 7-day.

**Switch 62.5WG® (cyprodinil, fludioxonil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 11-14 oz. per acre. REI: 12-hour. PHI: 7-day.

**Tanos® (famoxadone, cymoxanil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 8 oz. per acre. REI: 12-hour. PHI: 3-day.

**tebuconazole formulations (tebuconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* Monsoon®, Orius 3.6F®, Tebuzol 3.6F®, Toledo®, Vibe® are labeled. REI: see label. PHI: 7-day

**Vanguard WG® (cyprodinil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 10 oz. per acre. REI: 12-hour. PHI: 7-day.

**Viathon® (potassium phosphite, tebuconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 2-3 pts. per acre. REI: 12-hour. PHI: 7-day.

### ***Slippery Skin of Alliums - Burkholderia Bacteria***

Use pathogen-free seed. Rotate out of *Allium* species. Avoid overhead irrigation that might spread these diseases. Over-fertilizing with nitrogen can make the crop more susceptible. Avoid injuring bulbs and cut only when tops are dry.

Applying fixed copper products may reduce the spread of these diseases. For emerged annuals, apply before planting or crop emergence. Products labeled for

bacterial leaf blight may be helpful for other bacterial diseases, including bacterial flower stalk and leaf necrosis caused by *Pantoea agglomerans*.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Garlic, Leek, Onion (Dry), Onion (Green)* Several copper products are labeled at various rates. REI: see label. PHI: 0-day.

**ManKocide® (copper hydroxide, mancozeb)** *Garlic, Onion (Dry)* 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day.

### ***Smut of Onion - Urocystis Fungus***

**Crop rotation** *Garlic, Leek, Onion (Dry), Onion (Green)* Use a crop rotation of three years.

**Elixir® (mancozeb, chlorothalonil)** *Garlic, Onion (Dry)* 3-3.6 lbs. per acre. REI: 24-hour. PHI: 7-day.

**mancozeb formulations (mancozeb)** *Garlic, Onion (Dry)* Dithane®, Manzate®, Penncozeb® are labeled at various rates. Apply as an in-furrow drench at time of seedling. REI: 24-hour. PHI: 7-day.

### ***Sour Rot of Alliums - Burkholderia Bacteria***

Use pathogen-free seed. Rotate out of *Allium* species. Avoid overhead irrigation that might spread these diseases. Over-fertilizing with nitrogen can make the crop more susceptible. Avoid injuring bulbs and cut only when tops are dry.

Applying fixed copper products may reduce the spread of these diseases. For emerged annuals, apply before planting or crop emergence. Products labeled for bacterial leaf blight may be helpful for other bacterial diseases, including bacterial flower stalk and leaf necrosis caused by *Pantoea agglomerans*.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Garlic, Leek, Onion (Dry), Onion (Green)* Several copper products are labeled at various rates. REI: see label. PHI: 0-day.

**ManKocide® (copper hydroxide, mancozeb)** *Garlic, Onion (Dry)* 2.5 lbs. per acre. REI: 48-hour. PHI: 7-day.

### ***White Rot of Alliums - Sclerotium Fungus***

Dig out and destroy diseased plants as soon as you notice them. Wash equipment and footwear between fields to avoid transferring fungal propagules from infested fields.

**Sanitation** *Garlic, Leek, Onion (Dry), Onion (Green)*

Wash equipment and footwear between fields to avoid transferring fungal propagules from infested fields

**Cercobin® (thiophanate-methyl)** *Garlic, Onion (Dry)*

43.6 fl. oz. per acre. REI: see label. PHI: 3-day.

**Custodia® (azoxystrobin, tebuconazole)** *Garlic, Onion (Dry)*

32 fl. oz. per acre. One application via in-furrow or chemigation at planting. REI: 12-hour. PHI: 7-day.

**Custodia® (azoxystrobin, tebuconazole)** *Leek, Onion (Green)*

8.6-12.9 fl. oz. per acre. Suppression only. REI: 12-hour. PHI: 7-day.

**Fontelis® (pentiopyrad)** *Garlic, Leek, Onion (Dry), Onion (Green)* See label for pre-plant and broadcast options including rates. REI: 12-hour. PHI: 3-day.

**iprodione formulations (iprodione)** *Garlic* 4 pts. per acre. Iprodione 4L AG®, Meteor®, or Rovral 4 Flowable® are labeled. Use as in-furrow spray preplant. REI: 24-hour. PHI: 7-day.

**Luna Experience® (fluopyram, tebuconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 12.8 fl. oz. per acre. Suppression only. REI: 12-hour. PHI: 7-day.

**Luna Tranquility® (fluopyram, pyrimethanil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 27 fl. oz. per acre. Suppression only. REI: 12-hour. PHI: 7-day.

**Quadris Opti® (azoxystrobin, chlorothalonil)** *Onion (Dry)* 1.6-3.2 pts. per acre. REI: 12-hour. PHI: 7-day.

**Quilt Xcel® (azoxystrobin, propiconazole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 17.5-26 fl. oz. per acre. REI: 12-hour. PHI: 0-day for leek and green onion; 14-day for dry bulb and garlic.

**Switch 62.5WG® (cyprodinil, fludioxonil)** *Garlic, Leek, Onion (Dry), Onion (Green)* 11-14 oz. per acre. REI: 12-hour. PHI: 7-day.

**Topsin M WSB® (thiophanate-methyl)** *Garlic, Onion (Dry)* 2 lbs. per acre. REI: see label. PHI: 3-day.

## Weed Control

Onions and related crops pose challenges for weed control because the narrow leaves of the crop provide little shade to suppress weed growth, and, except for green onions, the crops grow for several months.

Designing bed and row spacing to fit equipment available for mechanical control will make weed management more efficient. When herbicides are used, multiple applications are often made. Other tools include careful

cultivation and hoeing, the use of plastic mulch for transplants, organic mulches, and flame weeding. A flamer can be used to control weeds that emerge after seeding and before the crop emerges. Some growers also use flaming successfully over the top of young onions or garlic, or directed toward the bases of larger plants even though some crop injury is likely with postemergence flaming.

For specific weeds controlled by each herbicide, check the Relative Effectiveness of Herbicides for Vegetable Crops table, page 68.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

## Recommended Controls

**Burndown or Directed/Shielded Application**

**Broadleaf and Grass Weeds**

**glyphosate formulations (glyphosate)** *Garlic, Leek, Onion (Dry), Onion (Green)* 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal) at 0.66-3.3 qts. per acre. Broadcast before planting, after planting but before crop emergence, or apply between crop rows with hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. REI: 4-hour. PHI: 14-day.

**paraquat formulations (paraquat)** *Garlic, Onion (Dry)* 2-4 pt. per acre of 2 lb. per gal. formulation. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS (0.25% v/v) per 25 gal. of solution and apply to emerged weeds less than 6" tall prior to transplanting or after direct-seeding but before crop emergence. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 24-hour. PHI: 60-day RUP.

**Burndown or Directed/Shielded Application**

**Broadleaf Weeds**

**Aim EC® (carfentrazone)** *Garlic, Leek, Onion (Dry), Onion (Green)* 0.5-2 fl. oz. per acre. Apply a minimum of 30 days prior to direct-seeding or with a hooded sprayer as a directed application between crop rows. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season. Do not allow spray to contact crop. REI: 12-hour. PHI: 0-day.

**Preemergence Broadleaf and Grass Weeds****Dual Magnum® (s-metolachlor) at the following rates:**

**Note:** Illinois, Indiana, Michigan, and Ohio only. Applicators must have 24c label. Illinois label expires December 31, 2020. Michigan and Ohio labels expire December 31, 2021. REI: 24-hour.

**Garlic, Leek, Onion (Green)** 0.67-1.3 pt. per acre.

Apply postemergence starting when the crop has 2 true leaves. Do not exceed 1.3 pts. per acre per season. PHI: 21-day.

**Onion (Dry)** 0.67-1.3 pt. per acre. Apply prior to weed emergence and when the crop has at least 2 true leaves. A second application may be applied 21 or more days after the first. Do not exceed 1.3 pts. per acre per application and 2.6 pt. per acre per crop. PHI: 60-day.

**Nortron SC® (ethofumesate) Onion (Dry)** 16-32 fl.

oz. per acre. Apply preemergence or soon after seeding before weeds germinate. May also be used postemergence. Do not exceed 4 applications or 48 fl. oz. per acre per season on coarse soils and 96 fl. oz. per acre per season on medium and fine soils. May cause temporary leaf fusion. May injure stressed plants. Use on mineral soils only. REI: 12-hour. PHI: 30-day.

**Outlook® (dimethenamid-p) Garlic, Leek, Onion (Dry), Onion (Green)** 12-21 fl. oz. per acre.

Apply after crop plants have 2 true leaves. For transplants, apply after transplanting when soil has settled around plants. See label for tank-mix recommendations. REI: 12-hour. PHI: 30-day.

**pendimethalin formulations (pendimethalin) at the following rates:**

**Garlic** Use Prowl H2O® or Satellite Hydrocap® at 1.5-3.2 pt. per acre or Prowl 3.3EC® at 1.8-3.6 pt. per acre after planting but before crop and weeds emerge, or when garlic has 1-5 true leaves. REI: 24-hour. PHI: 45-day.

**Leek, Onion (Green)** Use Prowl H2O® or Satellite Hydrocap® at 2 pts. per acre after seeding but before crop emerges (pre), or when crop has 2-3 true leaves (post). Will not control emerged weeds. If both pre and post applications are used, wait 30 days after pre application before making a post application. Only apply pre to muck soils (organic matter greater than 20%) or mineral soils with greater than 3% organic matter. Do not exceed 4 pts. per acre per year. *Michigan only:* Up to 4 pts. per acre Prowl H2O® may be used

on muck soils and mineral soils with more than 5% organic matter. *Applicator must have 24c label. Michigan label expires April 16, 2024.* Prowl 3.3EC is not labeled for green onions or leeks. REI: 24-hour. PHI: 30-day.

**Onion (Dry)** Use Prowl H2O® or Satellite Hydrocap® at 1.5-3.2 pts. per acre or Prowl 3.3EC® at 1.8-3.6 pts. per acre after planting but before crop and weeds emerge, or when onions have 2-9 true leaves. Use low rates on coarse soils. Heavy rain or excessive irrigation soon after application may cause crop injury. Muck soils only: Use up to 4 pts. per acre Prowl H2O® or Satellite Hydrocap® or up to 4.8 pts. per acre Prowl 3.3EC®. Do not exceed 12.6 pts. per acre Prowl H2O® or Satellite Hydrocap® or 14.4 pts. per acre Prowl 3.3EC®. *Michigan only:* For mineral soils with more than 10% organic matter, use 4 pts. per acre Prowl H2O® or Satellite Hydrocap® or 4.8 pts. per acre Prowl 3.3EC®. REI: 24-hour. PHI: 45-day.

**trifluralin formulations (trifluralin) Onion (Dry)** Use 4EC formulations at 0.75-1.25 pts. per acre. Use 10G formulations at 3.75-6.26 lbs. per acre. Apply at layby as a directed spray between onion rows and incorporate 1-2 inches. Mineral soils only (less than 3.5% organic matter). REI: 12-hour. PHI: 60-day.

**Preemergence Broadleaf Weeds****Chateau SW® (flumioxazin) at the following rates:**

**Garlic** 6 oz. per acre. Apply within 3 days after planting and before garlic emerges. Do not exceed 6 oz. per acre per growing season. Will not control emerged weeds. Do not tank mix with adjuvants or other herbicides. REI: 12-hour.

**Onion (Dry)** 2 oz. per acre. *Michigan only:* Apply to transplanted onions between the 2- and 6-leaf stage or to direct-seeded onions between the 3- and 6-leaf stage and prior to weed emergence. Do not exceed 2 oz. per acre per application or 3 oz. per acre per growing season. Will not control emerged weeds. Wait at least 14 days between repeat applications. Do not tank mix with adjuvants or other herbicides. REI: 12-hour. PHI: 45-day.

**GoalTender® (oxyfluorfen) Garlic, Onion (Dry) Seeded crops:** Broadcast 0.25 pt. per acre GoalTender® or 0.5 pt. per acre Goal 2XL® after crop has 2 true leaves. *Transplanted crops:* Broadcast 0.5-1 pt. per acre GoalTender or 1-2 pt. per acre Goal 2XL® prior to transplanting (onion only), or within 2 days of transplanting. Greenhouse-grown transplants may

**Herbicides for All Garlic, Onions, and Leeks<sup>1</sup>**

Product (REI/PHI)	Common Name	Timing and Application Location Relative to Crop <sup>2</sup>					Incorporated	Timing Relative to Weeds	Weed Groups Controlled		Crops <sup>3</sup>					
		Before seeding	After seeding before emergence	Before transplanting	Post emergence -between rows only	Postemergence			Preemergence	Postemergence	Annual grasses	Small-seeded broadleaves	Broadleaves	Garlic	Onion, dry bulb	Onion, green
Aim EC® (12h/-)	carfentrazone								X		X	X	X	X	X	X
Chateau® (24h/ 45d)	flumioxazin				X			X			X	X	X	X		
Dacthal W-75®, Dacthal® flowable (12h/-)	DCPA	X		X		X		X		X				X	X	X
Dual Magnum® (24h/21d)	s-metolachlor					X		X		X	X		X	X	X	
Fusilade® (12h/14 to 45d)	fluazifop					X				X	X			X	X	X
Goal® (12h/45d to 60d)	oxyfluorfen			X		X			X				X	X	X	
Gramoxone® (12h to 24h/-)	paraquat	X	X							X	X	X	X	X	*	*
Moxy® (12h/112d)	bromoxynil		X		X	X			X		X	X	X	X		
Nortron® (12h/)	norflurazon	X	X			X			X	X	X	X		X	X	
Outlook® (12h/30d)	dimethenamid-P					X			X		X	X	X	X	X	X
Poast® (12h/30d)	sethoxydim					X				X	X			X	X	X
Prefar 4E (12/-)	bensulide	X	X	X			yes	X		X			X	X		
Roundup®, others (12h/)	glyphosate	X	X	X	X				X	X	X	X	X	X	X	X
Satellite Hydrocap 3.8CS (24h/30 to 45d)	pendimethalin		X			X			X		X	X		X	X	X
Select Max®, others (12h/14d to 45d)	clethodim					X				X	X			X	X	X
Treflan®, others (12h/ 60d)	trifluralin				X		yes	X		X	X			X		

<sup>1</sup>For effectiveness against specific weeds, see Relative Effectiveness of Herbicides for Vegetable Crops (page 68), and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbicides can cause serious crop injury and yield loss if not used properly.

<sup>2</sup>X=permitted for at least one crop.

<sup>3</sup>X=may be used for that crop. \*=Direct-seeded crops only.

be sensitive to GoalTender® at transplanting. May cause foliar injury during cool weather. Use lower rate on coarse soils. Do not exceed 1 pt. per acre per season GoalTender® or 2 pt. per acre per season Goal 2XL. REI: see label. PHI: 45-day for onion, 60-day for garlic.

### Preemergence Grass Weeds

**Dacthal W75® (DCPA)** *Leek, Onion (Dry), Onion (Green)* Dacthal W75® at 6-14 lbs. per acre, or Dacthal Flowable® at 6-14 pts. per acre. Apply at seeding, transplanting, and/or layby. Preplant incorporation not recommended. May be sprayed over transplants. REI: 12-hour.

**Prefar 4E® (bensulide)** *Garlic, Onion (Dry)* 5-6 qt. per acre. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting. Or apply after seeding, before crop emerges and irrigate within 24 hours to incorporate. Mineral soils only. REI: 12-hour.

### Postemergence Broadleaf Weeds

**GoalTender® (oxyfluorfen)** See recommendations in the Preemergence Broadleaf Weeds section of this chapter.

**Moxy 2E® (bromoxynil)** *Garlic, Onion (Dry)* 1-1.5 pt. per acre for onion or 1.5-2 pt. per acre for garlic. Apply to weeds up to 2 in. tall and 1 in. wide with less than 4 leaves. Onion only: Apply when onions have 2-5 true leaves, using 50-70 gal. of water per acre, or on muck soils east of the Mississippi River only, apply 3-4 days before onions emerge. To minimize onion injury apply after 2 days of sunny weather when onion leaves are dry and temperatures are 70-80°F. Garlic only: Apply after garlic emerges and before it is 12 in. tall, using at least 20 gal. water per acre. REI: 24-hour. PHI: 45-day for onion, 112-day for garlic.

**Nortron SC® (ethofumesate)** See recommendations in the Preemergence Broadleaf and Grass Weeds section of this chapter.

**Starane Ultra® (fluroxypyr)** *Onion (Dry)* 5.6 fl. oz. per acre. *Michigan only* - applicators must have 24c label. Michigan label expires July 17, 2023. Apply to onions with 2-6 true leaves. Do not exceed 2 applications per season. Controls volunteer potato, chickweed, composites, nightshades, and mustards. REI: 24-hour. PHI: 42-day.

### Postemergence Grass Weeds

clethodim formulations (clethodim) at the following rates:

**Garlic, Onion (Dry)** Use 2 lb. per gal. formulations at 6-16 fl. oz. per acre with 1 qt. COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. per acre per season. Use 0.97 lb. per gal. formulations at 9-16 fl. oz. per acre to control annual grasses and 12-32 fl. oz. per acre to control perennial grasses. Add 0.5 pt. NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. per acre per season. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 45-day.

**Leek, Onion (Green)** Use 2 lb. per gal. formulations at 6-8 fl. oz. per acre with 1 qt. COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. per acre per season. Spray on actively growing grass. Wait at least 14 days between applications. Select Max® is not labeled for green onions or leeks. REI: 24-hour. PHI: 14-day.

**Fusilade DX® (fluazifop-P)** *Garlic, Leek, Onion (Dry), Onion (Green)* 10-12 fl. oz. per acre. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Apply to small actively growing grass. Do not exceed 48 fl. oz. per acre per year. REI: 12-hour. PHI: 45-day for garlic and onion (dry), 14-day for onion (green) and leek.

**Poast® (sethoxydim)** *Garlic, Leek, Onion (Dry), Onion (Green)* 1-1.5 pt. per acre. Add 1 qt. COC per 25 gal. of spray solution (1% v/v). Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4.5 pts. per acre per growing season. REI: 12-hour. PHI: 30-day.

## Insect Control

### Recommended Controls

#### Seed and Root Maggots

Correct planting time *Leek, Onion (Dry), Onion (Green)* Plant after the peak flight and egg-laying window of the first generation of flies looking to lay eggs around 700 GDD base 40.

**Healthy plant material** *Leek, Onion (Dry), Onion (Green)* Handle seeds carefully to prevent cracking.

**Moldboard plow** *Leek, Onion (Dry), Onion (Green)*  
Plow winter vegetation under early in the spring and thoroughly cover to limit attractiveness of rotting vegetation to the first generation of flies to lay eggs on.

**Ambush® (permethrin)** *Garlic, Onion (Dry)* 6.4-19.2 fl. oz. per acre foliar application. For adult control only. REI: 12-hour. PHI: 1-day. *RUP*.

**chlorpyrifos formulations (chlorpyrifos)** *Onion (Dry)*  
See Label. For 4E formulations use 1.1 fl. oz. per 1,000 linear ft. of row as an in-furrow drench at planting, or 1 qt. per acre as a postplant drench directed at base of plants during peak egg laying using 100 gallons per acre of water. For 15G formulations use 3.7 oz. per 1,000 linear ft. of row REI: see label. PHI: See Label. *RUP*.

**Diazinon AG500® (diazinon)** *Garlic, Leek, Onion (Dry), Onion (Green)* 2-4 qts. per acre. Broadcast just before planting and mix into top 3-4 inches of soil. Apply with sufficient water to drench seed furrow. Do not exceed 4 qts. per acre per season. PHI: 14-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** *Garlic, Leek, Onion (Dry), Onion (Green)* 2.24-4.0 fl. oz. per acre. For adult control only. Do not exceed 20 fl. oz. per acre per season. Allow 7 days between applications. Add COC at 16 fl. oz. per acre. REI: 12-hour. PHI: 7-day. *RUP*.

**Pounce 25WP® (permethrin)** *Garlic, Onion (Dry)* 6.4-19.2 oz. per acre for dry onion. 6.4-12.8 oz. per acre for garlic. For adult control only. Do not exceed 64 oz. per acre per season for dry onion. Do not exceed 51.2 oz. per acre per season for garlic. REI: 12-hour. PHI: 1-day. *RUP*.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** *Leek, Onion (Dry), Onion (Green)* Commercial seed treatments offered by seed companies include FarMore FI500® for dry bulb onions through Syngenta and CAPS (Coronet®, Allegience, Pro Gro®, and Sepresto®) on dry bulb onions, green bunch onions and leeks through Nunhem's.

**Warrior II (lambda-cyhalothrin)** *Garlic, Onion (Dry)* 0.96-1.6 fl. oz. per acre. For adult control only. Do not exceed 15.36 fl. oz. per acre per season. REI: 24-hour. PHI: 14-day. *RUP*.

### **Thrips**

Thresholds range from 1 thrips per leaf (Agri-Mek®, Exirel®, Minecto Pro®, Movento®, Lannate LV®) and 3 thrips per leaf (Radian®).

A suggested treatment schedule starts with two applications of Movento® for the first two weekly applications when the thrips population reaches the treatment threshold of 1 thrips per leaf for the first time of the season. Then, rotate products with two sequential weekly applications for each, reserving Radian® for high 3 thrips per leaf thresholds in peak season.

**Agri-Mek 0.15EC® (abamectin)** *Garlic, Leek, Onion (Dry), Onion (Green)* 1.75-3.5 fl. oz. per acre.

Supplemental label available for green onions and leeks. Use at 1 thrips per leaf threshold. Make 2 consecutive applications 7-days apart, then rotate to an insecticide with a different mode of action. Therefore, do not use in sequence before or after Minecto Pro® since it contains the same active ingredient. Do not exceed 14 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Ambush® (permethrin)** *Garlic, Onion (Dry)* 9.6-19.2 fl. oz. per acre foliar application. Use when thrips first appear. Not for rescue treatments. Many onion thrips populations have developed resistance to this insecticide, so efficacy will vary. REI: 12-hour. PHI: 1-day. *RUP*.

**Assail 30SG® (acetamiprid)** *Garlic, Leek, Onion (Dry), Onion (Green)* 5.0-8.0 oz. per acre. Do not exceed 4 applications per season. Many onion thrips populations have developed resistance to this insecticide, so efficacy will vary. REI: 12-hour. PHI: 7-day.

**Entrust SC® (spinosad)** *Garlic, Leek, Onion (Dry), Onion (Green)* 4.0-8.0 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season, or 5 applications. Allow 4 days between applications. REI: 4-hour. PHI: 1-day. OMRI-listed.

**Exirel® (cyantraniliprole)** *Garlic, Leek, Onion (Dry), Onion (Green)* 13.5-20.5 oz. per acre. Use at 1 thrips per leaf threshold. For suppression only. For best results, use highest rate listed. If thrips populations are high, use Radian before using Exirel. Tank mix with nonionic surfactant (0.25%-0.5% v/v) for best efficacy. Allow 5 days between applications. Do not make more than 2 consecutive applications before switching to another mode of action. Therefore, do not use in sequence before or after Minecto Pro® since it contains the same active ingredient. REI: 12-hour. PHI: 1-day.

**Lannate LV® (methomyl)** *Onion (Dry), Onion (Green)*

3 pts. per acre. Do not exceed 18 pts. per acre per season on green bunching onions, or 12 pts. per acre per season on dry bulb onions. REI: 48-hour. PHI: 7-day. *RUP*.

**Minecto Pro® (cyantraniliprole, abamectin) Garlic, Leek, Onion (Dry), Onion (Green)** 7.0-10 oz. per acre. Use at 1 thrips per leaf threshold. For suppression only. For best results, use highest rate listed. Not for rescue treatments. Tank mix with nonionic surfactant (0.25%-0.5% v/v) for best efficacy. Allow 5 days between applications. Do not make more than 2 consecutive applications before switching to another mode of action. Therefor, do not use in sequence before or after Exirel® or Agri-Mek® since these contain the same active ingredients. REI: 12-hour. PHI: 7-day for green onion and leek, 30-day for dry onion and garlic. *RUP*.

**Movento® (spirotetramat) Garlic, Leek, Onion (Dry), Onion (Green)** 5 oz. per acre. Use in June or July when populations reach the 1 thrips per leaf threshold for the first time of the season. Tank mix with nonionic surfactant (0.25%-0.5% v/v) for best efficacy. Allow 7 days between applications. Do not make more than 2 consecutive applications before switching to another mode of action. REI: 24-hour.

PHI: 3-day for dry onion and garlic, 7-day for green onion and leek.

**Pounce 25WP® (permethrin) Garlic, Onion (Dry)**

9.6-19.2 oz. per acre for dry onion. 9.6-12.8 oz. per acre for garlic. Many onion thrips populations have developed resistance to this insecticide, so efficacy may vary. Do not exceed 64 oz. per acre per season for dry onion. Do not exceed 51.2 oz. per acre per season for garlic. REI: 12-hour. PHI: 1-day. *RUP*.

**Radiant 1SC® (spinetoram) Garlic, Leek, Onion (Dry), Onion (Green)** 6-10 fl. oz. per acre. Use at 3 thrips per leaf threshold. Do not exceed 30 fl. oz. per acre per season or 5 applications. Do not make more than 2 consecutive applications before switching to another mode of action. REI: 4-hour. PHI: 1-day.

**Warrior II® (lambda-cyhalothrin) Garlic, Onion (Dry)**

1.28-1.92 fl. oz. per acre. Many onion thrips populations have developed resistance to this insecticide so efficacy may vary. Do not exceed 15.36 fl. oz. per acre per season. REI: 24-hour. PHI: 14-day. *RUP*.

## Example of Insecticide Rotation for Onion Thrips Management in Dry Bulb Onion

The table below provides an example of an insecticide rotation growers can use to manage onion thrips in dry bulb onion. It provides thresholds for use with each product.

Week	Product	Action Threshold
1	Movento®	1 thrips/leaf
2	Movento®	1 thrips/leaf
3	Agri-Mek®	1 thrips/leaf
4	Agri-Mek®	1 thrips/leaf
5	Radiant®	3 thrips/leaf
6	Radiant®	3 thrips/leaf
7	Lannate®	1 thrips/leaf
8	Lannate®	1 thrips/leaf

## IRAC Codes for Onion Thrips Control Products

The table below lists products labeled for onion thrips control and the Insecticide Resistance Action Code (IRAC) for each product.

Product	Active Ingredient	IRAC
Radiant SC®	spinetoram	5
Lannate LV®	methomyl	1A
Agri-Mek SC® or 0.15E	abamectin	6
Movento®	spirotetramat	23

# Potato

## Spacing

Rows 34 to 36 inches apart. Seed pieces 9 to 11 inches apart in row, depending on variety and intended use. Seed 16 to 18 100-pound bags per acre. Seed piece should be 1.5 to 2 ounces. Using B-size certified seed will save cutting labor and reduce tuber-borne diseases.

## Fertilizing

**Lime:** To control common scab, soil pH should be within 5.0 to 5.2. However, low soil pH reduces phosphorus availability and increases availability of toxic elements such as manganese and aluminum. If the field has a history of scab, using scab-resistant varieties is recommended. Then, the soil pH can be 6.5 where phosphorus is most available.

**Preplant:** N: none — only a small amount such as 24 to 30 pounds with the starter fertilizer.  $P_2O_5$ : none — apply 50 to 150 pounds as a starter depending on the soil test results.  $K_2O$ : 50 to 400 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. For the most efficient phosphate application, apply the fertilizer at planting in a band 2 to 3 inches to the side and below each side of the tuber. Examples would be 500 pounds per acre of 6-24-24 or 8-16-16. Do not apply more than 200 pounds of  $K_2O$  per acre in the band at planting. On sandy soils, broadcast 30 pounds or band 15 pounds sulfur per acre.

**Sidedress N:** For irrigated sandy soils, two split N applications are recommended: half at emergence and half at hilling or tuber initiation. For the early maturing varieties, use 50 to 60 pounds of N per acre at each growth stage. The second application can be adjusted according to rainfall and a petiole nitrate-N analysis. For upland or finer textured soils, all of the required N can be applied preplant or shortly after emergence. For soils with more than 3 percent organic matter and following soybeans, alfalfa, or a grass-legume hay crop, apply 100 pounds N per acre. For soils with less than 3 percent organic matter and the above rotation, apply 135 pounds N per acre. For potatoes following corn, rye, oats, wheat, or a vegetable crop, apply 150 pounds N per acre. Refer to University of Minnesota recommendations for N rates adjusted for yield goal.

## Vine Killing

Vine Killing Product	Treatment	Comments
Defol 750 <sup>*</sup>	3.2 qts. per acre in 10-20 gals. water by ground or 5-10 gals. by air.	Apply 10 days before harvest. Do not apply in extreme heat during middle of the day.
paraquat	0.8-1.5 pts. per acre of 2.5L or 0.6-1.0 pt. per acre of 3L in 50-100 gals. of water plus 1 gal. COC or 1-2 pts. nonionic surfactant per 100 gals. spray solution. <b>Not for potatoes to be stored or used for seed.</b>	Begin applications when leaves begin to turn yellow. Immature potato foliage and drought-stressed potato foliage are tolerant to this product. Maximum 3 pts. of 2.5L or 2 pts. of 3L per acre per season. For split applications, use lower rate and wait 5 days between applications. Read label for complete instructions. 3L formulation not for use in Iowa or Missouri. 3-day PHI.
Reglone <sup>*</sup>	1-2 pts. in 20-100 gals. water plus 8-64 fl. oz. nonionic surfactant.	A second application can be made if necessary. Allow at least 5 days between applications. 7-day PHI.
Rely 280 <sup>*</sup>	21 fl. oz. per acre. Not for potatoes to be used for seed.	Do not make more than 1 application. 9-day PHI.

## Chemical Sprout Control

Use maleic hydrazide (MH-30) according to label directions one week after blossoms fall. For varieties and conditions where flowering does not occur, apply four to six weeks before potatoes are mature and ready for harvest. Make only one application. Apply when no rain is expected for 24 hours. Potatoes treated with MH cannot be used for seed because sprouting will be inhibited. Follow label directions.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### **Black Dot of Potatoes - *Colletotrichum* Fungus**

**azoxystrobin formulations (azoxystrobin)** 6-15.5 fl. oz. per acre. Quadris<sup>\*</sup>, Satori<sup>\*</sup> and other azoxystrobin formulations are labeled. REI: 4-hour. PHI: 14-day.

**chlorothalonil formulations (chlorothalonil)** Bravo<sup>\*</sup>, Echo<sup>\*</sup>, Equus<sup>\*</sup>, and Initiate<sup>\*</sup> are labeled at various rates. REI: 12-hour. PHI: 7-day.

**Headline SC<sup>\*</sup> (pyraclostrobin)** 6-9 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**Luna Tranquility<sup>\*</sup> (fluopyram, pyrimethanil)** 8-11.2 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Miravis Prime<sup>\*</sup> (pydiflumetofen, fludioxonil)** 9.2-11.4 fl. oz. per acre. Black dot suppression only. REI: 12-hour. PHI: 14-day.

**Revus Top<sup>\*</sup> (mandipropamid, difenoconazole)** 5.5-7.0 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Tanos<sup>\*</sup> (famoxadone, cymoxanil)** 6-8 oz. per acre. Disease suppression only. REI: 12-hour. PHI: 14-day.

**Zing!<sup>\*</sup> (zoxamide, chlorothalonil)** 24-34 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

#### **Black Scurf of Potatoes - *Rhizoctonia* Fungus**

Always use a crop rotation of 2-3 years. Plant seed pieces certified to be free of disease. Harvest potatoes as soon after maturity as possible. Use a fungicide when appropriate.

**azoxystrobin formulations (azoxystrobin)** 0.4-0.8 fl. oz. per 1,000 ft. of row furrow. Formulations include Quadris<sup>\*</sup> and Satori<sup>\*</sup>. REI: 4-hour.

**Moncut<sup>\*</sup> (flutolanil)** 0.7-1.1 lbs. per acre. REI: 12-hour.

#### **Dry Rot of Potatoes - *Fusarium* Fungus**

Avoid bruising at harvest. Cure potatoes in storage at 60°F before lowering temperature. Provide adequate ventilation.

**mancozeb formulations (mancozeb)** 1 qt. per 50 gals. of water. Dip whole or cut potatoes in solution. REI: 24-hour.

**Mertect 340F<sup>\*</sup> (thiabendazole)** 0.42 oz. per 2,000 lbs. of tubers. REI: see label.

## **Early Blight of Potatoes - *Alternaria* Fungus**

Choose a cultivar with partial resistance to early blight. Avoid droughty, wet, or compacted soils, and other conditions (such as insufficient nitrogen) that might add undue stress to the crop and increase susceptibility to early blight. Rotate fields away from potato production for 2-3 years.

### **Group 11 Resistance**

Strains of the fungus that cause early blight that are resistant to group 11 fungicides have been observed. Group 11 products labeled for potato and early blight include Gem®, Headline®, and Quadris®, and Satori®. See Selected Information About Recommended Fungicides (page 79) for more information.

**azoxystrobin formulations (azoxystrobin)** 6-15.5 fl. oz. per acre. Quadris®, Satori®, and other azoxystrobin formulations are labeled. REI: 4-hour. PHI: 14-day.

**chlorothalonil formulations (chlorothalonil)** Bravo®, Echo®, Equus®, and Initiate® are labeled at various rates. REI: 12-hour. PHI: 7-day.

**Endura® (boscalid)** 3.5-4.5 oz. per acre. REI: 12-hour. PHI: 10-day.

**Gavel 75DF® (zoxamide, mancozeb)** 1.5-2 lbs. per acre. REI: 48-hour. PHI: 14-day.

**Headline SC® (pyraclostrobin)** 6-9 fl. oz. per acre. REI: 12-hour. PHI: 3-day.

**iprodione formulations (iprodione)** 1-2 pts. per acre. Several formulations of iprodione containing fungicides are available including Rovral® and Iprodione 4L®. REI: 24-hour. PHI: 14-day.

**Luna Tranquility® (fluopyram, pyrimethanil)** 8-11.2 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**mancozeb formulations (mancozeb)** REI: 24-hour. PHI: 14-day.

**Miravis Prime® (pydiflumetofen, fludioxonil)** 9.2-11.4 fl. oz. per acre. Black dot suppression only. REI: 12-hour. PHI: 14-day.

**Quadris Opti® (azoxystrobin, chlorothalonil)** 1.6 pts. per acre. REI: 12-hour. PHI: 14-day.

**Revus Top® (mandipropamid, difenoconazole)** 5.5-7.0 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Scala SC® (pyrimethanil)** 7 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Tanos® (famoxadone, cymoxanil)** 6 oz. per acre. REI: 12-hour. PHI: 14-day.

**Velum Prime® (fluopyram)** 6.5-6.84 fl. oz. per acre. Apply through overhead irrigation. REI: 12-hour. PHI: 7-day.

**Zing!® (zoxamide, chlorothalonil)** 24-34 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

## **Late Blight of Potatoes - *Phytophthora* Oomycete**

Destroy all potato cull piles.

The fungus that causes late blight does not overwinter in areas where hard freezes occur regularly. The fungus must be re-introduced on winds or plant material each year.

**chlorothalonil formulations (chlorothalonil)** Bravo®, Echo®, Equus®, and Initiate® are labeled at various rates. REI: 12-hour. PHI: 7-day.

**Curzate 60DF® (cymoxanil)** 3.2 oz. per acre. REI: 12-hour. PHI: 14-day.

**Gavel 75DF® (zoxamide, mancozeb)** 1.5-2 lbs. per acre. REI: 48-hour. PHI: 14-day.

**mancozeb formulations (mancozeb)** REI: 24-hour. PHI: 14-day.

**Omega 500F® (fluazinam)** 5.5 fl. oz. per acre. REI: see label. PHI: 14-day.

**Orondis Opti Premix® (oxathiapiprolin, chlorothalonil)** Follow rates on multipack container. Apply as a tank-mix of both products in multi-pack. REI: 12-hour. PHI: 7-day.

**Orondis Ultra Premix® (oxathiapiprolin, mandipropamid)** Follow rates given on each multi-pack container. Apply as a tank mix of both products in multi-pack. REI: 4-hour. PHI: 14-day.

**Previcur Flex® (propamocarb)** 0.7-1.2 pts. per acre. REI: 12-hour. PHI: 14-day.

**Ranman 400SC® (cyazofamid)** 1.4-2.75 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Revus Top® (mandipropamid, difenoconazole)** 5.5-7.0 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Tanos® (famoxadone, cymoxanil)** 6-8 oz. per acre. Disease suppression only. REI: 12-hour. PHI: 14-day.

**Zampro® (ametoctradin, dimethomorph)** 11-14 fl. oz. per acre. REI: 12-hour. PHI: 4-day.

**Zing!® (zoxamide, chlorothalonil)** 30-34 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

### **Root-Knot Nematode**

Sample fields during growing season for parasitic nematodes before planting. Avoid fields with high numbers of root-knot and/or lesion nematodes.

**Nimitz® (fluensulfone)** 3.5-7 pts. per acre. Apply at planting according to label. REI: see label.

**Telone II® (1,3-dichloropropene)** See label for rates. RUP. Other Telone formulations available. REI: see label. *RUP*.

**Vapam HL® (metam sodium)** See label for rates. REI: see label. *RUP*.

**Velum Prime® (fluopyram)** 6.5-6.84 fl. oz. per acre. Apply through overhead irrigation. REI: 12-hour. PHI: 7-day.

**Vydate L® (oxamyl)** 1-2 gals. per acre in 20 gals. of water broadcast. Incorporate 2-4 inches. RUP REI: 48-hour. PHI: 7-day. *RUP*.

### **Silver Scurf of Potatoes - *Helminthosporium* Fungus**

Always use a crop rotation of 2-3 years. Plant seed pieces certified to be free of disease. Harvest potatoes as soon after maturity as possible. Use a fungicide when appropriate.

**azoxystrobin formulations (azoxystrobin)** 0.4-0.8 fl. oz. per 1,000 ft. of row furrow. Formulations include Quadris® and Satori®. REI: 4-hour.

### **White Mold (Timber Rot) of Multiple Crops - *Sclerotinia* Fungus**

Avoid excess nitrogen. Reduce overhead irrigation if disease is present.

**Contans WG® (Coniothyrium minitans)** Apply immediately after harvest or 3-4 months before planting. REI: 4-hour. *OMRI-listed*.

**Endura® (boscalid)** 5.5-10 oz. per acre. REI: 12-hour. PHI: 10-day.

**iprodione formulations (iprodione)** 2 pts. per acre. Several formulations are available including Rovral® and Iprodione 4L®. REI: 24-hour. PHI: 14-day.

**Luna Tranquility® (fluopyram, pyrimethanil)** 11.2 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Omega 500F® (fluazinam)** 5.5-8 fl. oz. per acre. REI: see label. PHI: 14-day.

**Topsin 4.5FL® (thiophanate-methyl)** 20-30 fl. oz. per acre. REI: see label. PHI: 21-day PHI.

*OMRI-listed* indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.

**Velum Prime® (fluopyram)** 6.5-6.84 fl.oz. per acre.

Apply through overhead irrigation. REI: 12-hour. PHI: 7-day.

## **Weed Control**

Potato cultural practices offer several good opportunities to control weeds, beginning with the period between planting and emergence (when early-emerging weeds can be killed with an herbicide or flaming), and continuing through the hilling process (when weeds can be buried or cultivated out). Some organic farmers also use flaming after potatoes emerge because some injury to the potato foliage early in the season can be tolerated. A relatively large number of herbicides are labeled for use on potatoes.

For specific weeds controlled by each herbicide, check Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

### **Recommended Controls**

#### **Burndown or Directed/Shielded Applications**

##### **Broadleaf and Grass Weeds**

**glyphosate formulations (glyphosate)** 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before planting, after planting before ground cracks, or apply between crop rows with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. REI: 4-hour. PHI: 14-day.

**Gramoxone SL 2.0® (paraquat)** 1-2 pts. per acre. Use 1 qt. of COC, or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before planting, or after planting but before ground cracks. REI: see label. *RUP*.

#### **Burndown or Directed/Shielded Applications**

##### **Broadleaf Weeds**

**Aim EC® (carfentrazone)** 0.5-2 fl. oz. per acre. Apply prior to or within 24 hours of planting, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Preemergence Broadleaf and Grass Weeds****Dual Magnum® or Dual II Magnum® (s-metolachlor)**

1-2 pts. per acre. Use lower rates on coarse soils.

Apply and incorporate before planting, or apply after planting before weeds emerge. May also be applied at 1.67 pts. per acre after hilling. Dual Magnum might delay maturity and/or reduce yield of Superior and other early maturing varieties if cold, wet soil conditions occur after treatment. Dual Magnum® can be tank-mixed with Lorox®, Sencor®, Prowl®, or Eptam®. See labels. Do not exceed 3.6 pts. per acre. REI: 24-hour. PHI: 60-day if applied before drag-off, or 40-day if applied at lay-by.

**Eptam® (EPTC)** Use Eptam 7E® at 3.5-7 pts. per acre, or Eptam 20G® at 15-20 lbs. per acre. Apply before planting, after drag-off, or as directed spray at lay-by. Incorporate immediately. On muck soils, supplement with linuron or metribuzin products applied before crop emerges and after drag-off. The Superior variety may be sensitive. Suppresses nutsedge. REI: 12-hour. PHI: 45-day.

**linuron formulations (linuron)** Use 50DF formulations at 1.5-3 lbs. per acre. Use 4L formulations at 1.5-4 pts. per acre. Also controls small, emerged weeds. Apply after planting but before crop emergence, when weeds are less than 2 inches tall. Seed pieces must be planted at least 2 inches deep. Do not use on sand, loamy sand, or soils with less than 1 percent organic matter. REI: see label.

**Matrix SG® (rimsulfuron)** 1-1.5 oz. per acre. Typically combined with full-labeled rates of metribuzin to improve spectrum of broadleaf control. Use 0.5 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Apply after planting before crop emerges, at hilling, drag-off, or reservoir tillage, to a clean, newly prepared seedbed. Apply post when weeds are less than 1 inch tall. Avoid using adjuvants when potatoes are under heat stress. Do not exceed 2.5 oz. per acre per year. REI: 4-hour. PHI: 30-day.

**metribuzin formulations (metribuzin)** Use 4F formulations at 0.5-2 pts. per acre, or 75DF formulations at 0.33-1.32 lbs. per acre. *Not for early-maturing or red-skinned varieties.* Apply after planting before crop emerges, or apply up to 1 pt. of metribuzin 4F (1.32 lbs. of 75DF formulations) after emergence. Check label for sensitive varieties. Avoid spraying when potatoes are 12-15 inches tall. Do not apply within 3 days of cool, wet, or cloudy weather,

or crop injury may occur. Do not apply within 1 day of other pesticide applications. Do not exceed 2 pts. of 4F formulations or 1.32 lbs. of 75DF formulations per acre per year. REI: 12-hour. PHI: 60-day.

**Outlook® (dimethenamid-p)** 12-21 fl. oz. per acre. Apply after planting or drag-off and before weeds emerge. In cold and wet conditions potatoes may emerge slowly or be stunted. May be tank-mixed with a number of other potato herbicides. REI: 12-hour. PHI: 40-day.

**pendimethalin formulations (pendimethalin)** Use 3.8ME formulations at 1.5-3 pts. per acre. Use 3.3EC formulations at 1.2-3.6 pts. per acre. Use low rates on coarse soils. Broadcast after planting but before emergence or drag-off, or after potatoes have fully emerged before potatoes are 6 inches tall. May be incorporated. Not effective on muck soils. Do not apply postemergence to stressed potatoes REI: 24-hour.

**trifluralin formulations (trifluralin)** Use 4EC formulations at 1-2 pts. per acre. Use 10G formulations at 5-10 lbs. per acre. Broadcast and incorporate 1-2 inches after planting but before emergence, immediately after drag-off, or after potatoes have fully emerged. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour.

**Zidua® (pyroxasulfone)** Use 2.5-3.25 fl. oz. per acre of SC formulation. Use 1.5-2.0 oz. per acre of WG formulation. Apply after planting and before potatoes emerge. Use with another herbicide. Some varieties may be sensitive to Zidua. REI: 12-hour.

**Preemergence Broadleaf Weeds**

**Chateau SW® (flumioxazin)** 1.5 oz. per acre. Minnesota only -- supplemental label. Apply to potatoes after hilling. A minimum of 2 inches of soil must cover vegetative plant parts when applied to avoid injury. Provides suppression of lambsquarters, nightshades, pigweeds, wild mustard, and wild radish. Tank-mixes recommended to improve efficacy. REI: 12-hour.

**League® (imazosulfuron)** 4.0-6.4 oz. per acre. Apply after planting crop and before crop emerges, or immediately after hilling. Or use 3.2 oz. per acre and after at least 21 days make a second application of 3.2 oz. per acre to control emerged weeds less than 3 inches tall. Or use 3.2-4 oz. per acre after crop emerges and before weeds are 3 inches tall; combine this with other measures to achieve satisfactory

control. When emerged weeds are present use a Valent-recommended surfactant. Use the high rate in fields with a known history of nutsedge. Do not exceed two applications and 6.4 oz. per acre per year. REI: 12-hour. PHI: 45-day.

**Reflex® (fomesafen)** 1 pt. per acre. Broadcast after planting and before potatoes emerge. When using on any variety for the first time, first determine whether

### Herbicides for Potatoes<sup>1</sup>

Product (REI/PHI)	Common Name	Timing and Application Location Relative to Crop <sup>2</sup>						Timing Relative to Weeds	Weed Groups Controlled		Comments	
		Before planting	After planting before ground cracks	At/after Drag-off	At/after hilling	Between rows, directed/shielded	Postemergence over potato crop		Premergence	Postemergence		
Aim® (12h/-)	carfentrazone	X				X			X		X	X
Chateau® (12h/-)	flumioxazin				X			X			X	X
Dual (II) Magnum® (12h/40d to 60d)	s-metolachlor	X	X	X	X			X		X	X	
Eptam® (12h45d)	EPTC	X		X		X		X		X		Incorporate.
Gramoxone® (12h to 24h/-)	paraquat	X	X						X	X	X	X
League® (12h/45d)	imazosulfuron		X		X		X	X	X		X	X
Linuron products (12h/-)	linuron		X					X	X	X	X	X
Matrix® (4h/60d)	rimsulfuron		X	X	X			X	X	X	X	X
Metribuzin products (12h/60d)	metribuzin		X				X	X		X	X	X
Outlook® (12h/40d)	dimethenamid-P		X	X				X		X	X	
Pendimethalin products (12h/ -)	pendimethalin		X				X	X		X	X	
Poast® (12h/30d)	sethoxydim	X	X	X	X		X		X	X		
Reflex® (12h/70d)	fomesafen		X					X			X	X
Roundup®, others (12h/14d)	glyphosate	X	X			X			X	X	X	X
Select Max®, others (12h/30d)	clethodim	X	X	X	X		X		X	X		
Treflan®, others (12h/-)	trifluralin		X	X				X		X	X	Incorporate.

<sup>1</sup>For effectiveness against specific weeds, see Relative Effectiveness of Herbicides for Vegetable Crops (page 68), and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbicides can cause serious crop injury and yield loss if not used properly.

<sup>2</sup>X=permitted on label.

the variety is tolerant to this herbicide. May be tank-mixed with other preemergence herbicides. May not be used on the same land the following year. Alfalfa and most vegetables should not be planted for 18 months. REI: 24-hour. PHI: 70-day.

### **Postemergence Broadleaf and Grass Weeds**

**linuron (linuron)** See details above for preemergence broadleaves and grasses.

**Matrix SG® (rimsulfuron)** See details above for preemergence broadleaves and grasses.

### **Postemergence Broadleaf Weeds**

**Aim EC® (carfentrazone)** See details above for Burndown or Directed/Shielded Applications Broadleaf Weeds.

**League® (imazosulfuron)** See details above for Preemergence Broadleaf Weeds.

**metribuzin formulations (metribuzin)** See details above for Preemergence Broadleaf and Grass Weeds.

### **Postemergence Grass Weeds**

**clethodim formulations (clethodim)** Use 2EC formulations at 6-16 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max® at 9-32 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of Select Max® per acre per season. REI: 24-hour. PHI: 30-day.

**Poast® (sethoxydim)** 1.0-2.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5 pts. per acre per season. REI: 12-hour. PHI: 30-day.

## **Insect Control**

### **Recommended Controls**

#### **Aphids**

**M-Pede® (potassium salts of fatty acids)** 1-2% by volume. Must contact aphids to be effective. Combine with another labeled product for best results. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Actara® (thiamethoxam)** 1.5-3.0 oz. per acre. Do not exceed 6 oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 14-day.

*OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.*

**Admire Pro® (imidacloprid)** Seed piece treatment: 0.17-0.35 fl. oz. per 100 lbs. of seed applied directly to seed pieces. Soil application: 5.7-8.7 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. Do not exceed 8.7 fl. oz. per acre per season from seed or soil applications. Foliar application: 1.3 fl. oz. per acre applied to foliage. Do not exceed 5.6 fl. oz. per acre per season from foliar applications. See pollinator precautions. REI: 12-hour. PHI: 7-day for foliar applications.

**Ambush® (permethrin)** 3.2-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. REI: 12-hour. RUP.

**Asana XL® (esfenvalerate)** 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**Assail 30SG® (acetamiprid)** 2.5-4.0 oz. per acre. Do not exceed 4 applications per year, or 16 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Athena® (bifenthrin, abamectin)** 7-17 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. po RUP.

**Belay® (clothianidin)** Seed piece treatment: 0.4-0.6 fl. oz. per 100 lbs. of seed applied directly to seed pieces. Soil application: 9-12 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. Do not exceed 12 fl. oz. per acre per season from seed or soil applications. Foliar application: 2-3 fl. oz. per acre applied to foliage. Do not exceed 12 fl. oz. per acre per season from foliar applications. Allow 7 days between applications. See pollinator precautions. REI: 12-hour. PHI: 14-day.

**Beleaf 50SG® (flonicamid)** 2.0-2.8 oz. per acre. Do not exceed 8.4 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Dimethoate 4E® (dimethoate)** 0.5-1.0 pt. per acre. Do not exceed 2 pts. per acre per season. Allow 7 days between application. REI: 48-hour. PHI: 0-day.

**Fulfill® (pyrimetzone)** 2.75-5.5 oz. per acre. Do not exceed 11 oz. per acre per season. Allow 7-days between applications. REI: 12-hour. PHI: 14-day.

**Lannate LV® (methomyl)** 1.5-3.0 pts. per acre. Do not exceed 15 pts. per acre per season. REI: 48-hour. PHI: 6-day. RUP.

**Movento® (spirotetramat)** 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. Allow 7 days between applications. REI: 24-hour. PHI: 7-day.

**Mustang Maxx® (zeta-cypermethrin)** 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 4 days between applications. REI: 12-hour. PHI: 1-day. *RUP*.

**Platinum 2SC® (thiamethoxam)** 5-8 fl. oz. per acre. Apply as in-furrow spray during planting, as a directed spray to base of plant at emergence, as a broadcast spray during last hillling operation, or as an overhead chemigation after last hillling. Do not exceed 8 fl. oz. per acre per season. Make only one application per season. REI: 12-hour. PHI: NA

**Scorpion 35SL® (dinotefuran)** Soil application: 11.5-13.25 fl. oz. per acre applied in-furrow at planting, or side-dressed to both sides of the row at ground crack. Do not exceed 13.25 fl. oz. per acre per season from seed or soil applications. Foliar application: 2.0-2.75 fl. oz. per acre applied to foliage. Do not exceed 8.0 fl. oz. per acre per season from foliar applications. Allow 14 days between applications. See pollinator precautions. REI: 12-hour. PHI: 7-day.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** See label. Rates vary by product. Choose seed treatments that include thiamethoxam insecticide (Cruiser 5FS®, Cruiser Maxx®, and Cruiser Maxx Potato®). For best results, plant potatoes immediately after treatment. PHI: See label.

**Sivanto 200SL® (flupyradifurone)** 7.0-10.5 fl. oz. per acre. Do not exceed 28.0 fl. oz. per acre per season. Allow 7 days between applications. REI: 4-hour. PHI: 7-day.

**Thimet 20G® (phorate)** Light or sandy soils: 8.5-11.3 oz. per 1,000 ft. of row for any row spacing larger than 32-inches. Use at planting or postemergence. Heavy or clay soils: 13.0-17.3 oz. per 1,000 ft. of row. Do not use post emergence. Apply as a band application on each side of row and beneath soil surfaces, or in the seed furrow. REI: 48-hour. PHI: 90-day. *RUP*.

**Torac 15EC® (tolfenpyrad)** 17-21 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per season, or 2 applications. Allow 14 days between applications. See pollination precautions. REI: 12-hour. PHI: 14-day.

**Transform WG® (sulfoxaflor)** 0.75-1.5 oz. per acre. Do not exceed 8.5 oz. per acre per season. Allow 14 days between applications. REI: 24-hour. PHI: 7-day.

**Voliam Flexi® (thiamethoxam, chlorantraniliprole)** 4 oz. per acre. Do not exceed 8 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 14-day.

**Vydate C-LV® (oxamyl)** 17-34 fl. oz. per acre. Do not exceed 306 fl. oz. per acre per season, or 8 applications per crop. Allow 14 days between applications. In Kansas do not exceed 204 fl. oz. per acre per season, or 4 applications per crop. Allow 14 days between applications. REI: 48-hour. PHI: 7-day. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

### **Colorado Potato Beetle**

**Actara® (thiamethoxam)** 1.5-3.0 oz. per acre. Do not exceed 6 oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 14-day.

**Admire Pro® (imidacloprid)** Seed piece treatment: 0.17-0.35 fl. oz. per 100 lbs. of seed applied directly to seed pieces. Soil application: 5.7-8.7 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. Do not exceed 8.7 fl. oz. per acre per season from seed or soil applications. Foliar application: 1.3 fl. oz. per acre applied to foliage. Do not exceed 5.6 fl. oz. per acre per season from foliar applications. See pollinator precautions. REI: 12-hour. PHI: 7-day for foliar applications.

**Agri-Mek SC® (abamectin)** 1.7-3.5 fl. oz. per acre. Do not exceed 10.25 fl. oz. per acre per season. REI: 12-hour. PHI: 14-day. *RUP*.

**Ambush® (permethrin)** 3.2-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. REI: 12-hour. *RUP*.

**Asana XL® (esfenvalerate)** 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Assail 30SG® (acetamiprid)** 1.5-4.0 oz. per acre. Do not exceed 4 applications per year, or 16 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Athena® (bifenthrin, abamectin)** 7-17 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. *po RUP*.

**Avaunt® 30WDG (indoxacarb)** 3.5-6.0 oz. per acre. Do not exceed 24 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

## Colorado Potato Beetle Resistance Management

In some areas of the Midwest, Colorado potato beetle populations are resistant to many insecticides. If a previously effective insecticide is no longer effective, consider switching to another chemical class. If insecticides are still effective, alternating between classes will help prolong their effective lives. If planting time applications of neonicotinoids (Admire Pro®, Gaucho®, Genesis®, Platinum®) are used, foliar neonicotinoids (Actara®, Leverage®) should not be used.

The following table shows the active ingredients and chemical classes of Colorado potato beetle insecticides, and should be used to make resistant management decisions. To avoid promoting insect resistance, make sure to rotate between products that have different Insecticide Resistance Action Committee (IRAC) Group Numbers.

Insecticide	Active Ingredient	Chemical Class	IRAC Group Number
Actara®	thiamethoxam	neonicotinoid	4A
Platinum®	thiamethoxam	neonicotinoid	4A
Admire Pro®	imidacloprid	neonicotinoid	4A
Assail®	acetamiprid	neonicotinoid	4A
Belay®	clothianidin	neonicotinoid	4A
Genesis®	imidacloprid	neonicotinoid	4A
Gaucho®	imidacloprid	neonicotinoid	4A
Leverage®	imidacloprid + cyfluthrin	neonicotinoid + pyrethroid	4A + 3
Endigo ZC®	thiamethoxam = lambda cyhalothrin	neonicotinoid + pyrethroid	4A + 3
Baythroid XL®	cyfluthrin	pyrethroid	3
Ambush®	permethrin	pyrethroid	3
Pounce®	permethrin	pyrethroid	3
Warrior II®	lambda cyhalothrin	pyrethroid	3
Agri-Mek®	abamectin	GABA agonist	6
Epi-Mek®	abamectin	GABA agonist	6
Monitor®	methomidaphos	organophosphate	1B
Kryocide®, Cryolite®	sodium aluminofluoride	mineral	9A
M-Trak®, Novodor®, Raven®	<i>Bacillus thuringiensis</i>	bacterium	11C
Entrust®	spinosad	spinosyn	5
Radiant®	spinetoram	spinosyn	5
Rimon®	novaluron	chitin biosynthesis inhibitor	15
Torac®	tolfenpyrad	mitochondrial complex I electron transport inhibitors	21A
Coragen®	chlorantraniliprole	anthanilic diamide	28
Voliam Flexi®	chlorantraniliprole + thiamethoxam	anthanilic diamide + neonicotinoid	28 + 4A
Voliam Xpress®	chlorantraniliprole + lambda cyhalothrin	anthanilic diamide = pyrethroid	28 + 3

**Belay® (clothianidin)** Seed piece treatment: 0.4-0.6 fl. oz. per 100 lbs. of seed applied directly to seed pieces. Soil application: 9-12 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. Do not exceed 12 fl. oz. per acre per season from seed or soil applications. Foliar application: 2-3 fl. oz. per acre applied to foliage. Do not exceed 12 fl. oz. per acre per season from foliar applications. Allow 7 days between applications. See pollinator precautions. REI: 12-hour. PHI: 14-day.

**Blackhawk® (spinosad)** 1.7-3.3 oz. per acre. Do not exceed 14.4 oz. per acre per season. Allow 7 days between applications. REI: 4-hour. PHI: 7-day.

**Coragen® (chlorantraniliprole)** 3.5-7.5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. Allow 5 days between applications. REI: 4-hour. PHI: 14-day.

**Endigo ZC® (thiamethoxam, lambda-cyhalothrin)** 3.5-4.5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. Allow 7 days between applications. REI: 24-hour. PHI: 14-day. *RUP*.

**Entrust® (spinosad)** 3-10 fl. oz. per acre. Do not exceed 21 fl. oz. per acre per season. Allow 7 days between applications. Tolerance/resistance has been observed in Minnesota. Follow resistance management restrictions. REI: 4-hour. PHI: 7-day. *OMRI-listed*.

**Mustang Maxx® (zeta-cypermethrin)** 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 4 days between applications. REI: 12-hour. PHI: 1-day. *RUP*.

**Novodor FC® (Bacillus thuringiensis tenebrionis strain NB-176)** 1-4 qts. per acre. Effective on small (up to 1/4 inch) larvae only. Use higher rate for mixed sizes or heavier infestations. REI: 4-hour. PHI: 0-day.

**Platinum 2SC® (thiamethoxam)** 5-8 fl. oz. per acre. Apply as in-furrow spray during planting, as a directed spray to base of plant at emergence, as a broadcast spray during last hillling operation, or as an overhead chemigation after last hillling. Do not exceed 8 fl. oz. per acre per season. Make only one application per season. REI: 12-hour. PHI: NA

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 6.4 lbs. per acre per season. Allow 10 days between applications. REI: 12-hour. PHI: 14-day. *RUP*.

**Radiant 1SC® (spinetoram)** 4.5-8 fl. oz. per acre. Do not exceed 32 fl. oz. per acre. Allow 7 days between applications. REI: 4-hour. PHI: 7-day.

**Rimon 0.83EC® (novaluron)** 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 14-day.

**Scorpion 35SL® (dinotefuran)** Soil application: 11.5-13.25 fl. oz. per acre applied in-furrow at planting, or side-dressed to both sides of the row at ground crack. Do not exceed 13.25 fl. oz. per acre per season from seed or soil applications. Foliar application: 2.0-2.75 fl. oz. per acre applied to foliage. Do not exceed 8.0 fl. oz. per acre per season from foliar applications. Allow 14 days between applications. See pollinator precautions. REI: 12-hour. PHI: 7-day.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** See label. Rates vary by product. Choose seed treatments that include thiamethoxam insecticide (Cruiser 5FS®, Cruiser Maxx®, and Cruiser Maxx Potato®). For best results, plant potatoes immediately after treatment. PHI: See label.

**Sevin XLR Plus® (carbaryl)** 1.0-2.0 qts. per acre. Some Colorado Potato Beetle populations are resistant to carbaryl, so results may vary. Do not exceed 6 qts. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 7-day.

**Sivanto 200SL (flupyradifurone)** 10.5-14.0 fl. oz. per acre. Do not exceed 28.0 fl. oz. per acre per season. Allow 7 days between applications. REI: 4-hour. PHI: 7-day.

**Thimet 20G® (phorate)** Light or sandy soils: 8.5-11.3 oz. per 1,000 ft. of row for any row spacing larger than 32-inches. Use at planting or postemergence. Heavy or clay soils: 13.0-17.3 oz. per 1,000 ft. of row. Do not use post emergence. Apply as a band application on each side of row and beneath soil surfaces, or in the seed furrow. REI: 48-hour. PHI: 90-day. *RUP*.

**Torac 15EC® (tolfenpyrad)** 14-21 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per season, or 2 applications. Allow 14 days between applications. See pollination precautions. REI: 12-hour. PHI: 14-day.

**Voliam Flexi® (thiamethoxam, chlorantraniliprole)** 4 oz. per acre. Do not exceed 8 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 14-day.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

**Cutworm Caterpillars**

**Ambush® (permethrin)** 3.2-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. REI: 12-hour. *RUP.*

**Asana XL® (esfenvalerate)** 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP.*

**Baythroid XL® (beta-cyfluthrin)** 0.8-1.6 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP.*

**Endigo ZC® (thiamethoxam, lambda-cyhalothrin)** 3.5-4.5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. Allow 7 days between applications. REI: 24-hour. PHI: 14-day. *RUP.*

**Lannate LV® (methomyl)** 1.5 pts. per acre. Do not exceed 15 pts. per acre per season. REI: 48-hour. PHI: 6-day. *RUP.*

**Mustang Maxx® (zeta-cypermethrin)** 1.28-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 4 days between applications. REI: 12-hour. PHI: 1-day. *RUP.*

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 6.4 lbs. per acre per season. Allow 10 days between applications REI: 12-hour. PHI: 14-day. *RUP.*

**Sevin XLR Plus® (carbaryl)** 1.0-2.0 qts. per acre. Some Colorado Potato Beetle populations are resistant to carbaryl, so results may vary. Do not exceed 6 qts. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 7-day.

**Warrior II® (lambda-cyhalothrin)** 0.96-1.60 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP.*

**European Corn Borer Caterpillar**

**Ambush® (permethrin)** 3.2-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. REI: 12-hour. *RUP.*

**Asana XL® (esfenvalerate)** 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP.*

**Assail 30SG® (acetamiprid)** 2.5-4.0 oz. per acre. Do not exceed 4 applications per year, or 16 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Athena® (bifenthrin, abamectin)** 7-17 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. *po RUP.*

**Avaunt 30WDG® (indoxacarb)** 3.5-6.0 oz. per acre. Do not exceed 24 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP.*

**Blackhawk® (spinosad)** 1.7-3.3 oz. per acre. Do not exceed 14.4 oz. per acre per season. Allow 7 days between applications. REI: 4-hour. PHI: 7-day.

**Coragen® (chlorantraniliprole)** 3.5-7.5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. Allow 5 days between applications. REI: 4-hour. PHI: 14-day.

**Endigo ZC® (thiamethoxam, lambda-cyhalothrin)** 4-4.5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. Allow 7 days between applications. REI: 24-hour. PHI: 14-day. *RUP.*

**Entrust® (spinosad)** 3-10 fl. oz. per acre. Do not exceed 21 fl. oz. per acre per season. Allow 7 days between applications. Tolerance/resistance has been observed in Minnesota. Follow resistance management restrictions. REI: 4-hour. PHI: 7-day. *OMRI-listed.*

**Mustang Maxx® (zeta-cypermethrin)** 1.76-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 4 days between applications. REI: 12-hour. PHI: 1-day. *RUP.*

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 6.4 lbs. per acre per season. Allow 10 days between applications REI: 12-hour. PHI: 14-day. *RUP.*

**Radiant 1SC® (spinetoram)** 6-8 fl. oz. per acre. Do not exceed 32 fl. oz. per acre. Allow 7 days between applications. REI: 4-hour. PHI: 7-day.

**Rimon 0.83EC® (novaluron)** 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 14-day.

**Sevin XLR Plus® (carbaryl)** 1.0-2.0 qts. per acre. Some Colorado Potato Beetle populations are resistant to carbaryl, so results may vary. Do not exceed 6 qts. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 7-day.

**Voliam Flexi® (thiamethoxam, chlorantraniliprole)** 4 oz. per acre. Do not exceed 8 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 14-day.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP.*

## Flea Beetles

**Actara® (thiamethoxam)** 1.5-3.0 oz. per acre. Do not exceed 6 oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 14-day.

**Admire Pro® (imidacloprid)** Seed piece treatment: 0.17-0.35 fl. oz. per 100 lbs. of seed applied directly to seed pieces. Soil application: 5.7-8.7 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. Do not exceed 8.7 fl. oz. per acre per season from seed or soil applications. Foliar application: 1.3 fl. oz. per acre applied to foliage. Do not exceed 5.6 fl. oz. per acre per season from foliar applications. See pollinator precautions. REI: 12-hour. PHI: 7-day for foliar applications.

**Asana XL® (esfenvalerate)** 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Assail 30SG® (acetamiprid)** 1.5-2.5 oz. per acre. Do not exceed 4 applications per year, or 16 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Athena® (bifenthrin, abamectin)** 7-17 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. *po RUP*.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Belay® (clothianidin)** Seed piece treatment: 0.4-0.6 fl. oz. per 100 lbs. of seed applied directly to seed pieces. Soil application: 9-12 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. Do not exceed 12 fl. oz. per acre per season from seed or soil applications. Foliar application: 2-3 fl. oz. per acre applied to foliage. Do not exceed 12 fl. oz. per acre per season from foliar applications. Allow 7 days between applications. See pollinator precautions. REI: 12-hour. PHI: 14-day.

**Endigo ZC® (thiamethoxam, lambda-cyhalothrin)** 3.5-4.5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. Allow 7 days between applications. REI: 24-hour. PHI: 14-day. *RUP*.

**Lannate LV® (methomyl)** 1.5 pts. per acre. Do not exceed 15 pts. per acre per season. REI: 48-hour. PHI: 6-day. *RUP*.

**Platinum 2SC® (thiamethoxam)** 5-8 fl. oz. per acre. Apply as in-furrow spray during planting, as a directed spray to base of plant at emergence, as a broadcast spray during last hilling operation, or as an overhead chemigation after last hilling. Do not

exceed 8 fl. oz. per acre per season. Make only one application per season. REI: 12-hour. PHI: NA

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 6.4 lbs. per acre per season. Allow 10 days between applications REI: 12-hour. PHI: 14-day. *RUP*.

**Scorpion 35SL® (dinotefuran)** Soil application: 11.5-13.25 fl. oz. per acre applied in-furrow at planting, or side-dressed to both sides of the row at ground crack. Do not exceed 13.25 fl. oz. per acre per season from seed or soil applications. Foliar application: 2.0-2.75 fl. oz. per acre applied to foliage. Do not exceed 8.0 fl. oz. per acre per season from foliar applications. Allow 14 days between applications. See pollinator precautions. REI: 12-hour. PHI: 7-day.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** See label. Rates vary by product. Choose seed treatments that include thiamethoxam insecticide (Cruiser 5FS®, Cruiser Maxx®, and Cruiser Maxx Potato®). For best results, plant potatoes immediately after treatment. PHI: See label.

**Sevin XLR Plus® (carbaryl)** 0.5-1.0 qts. per acre. Do not exceed 6 qts. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 7-day.

**Thimet 20G® (phorate)** Light or sandy soils: 8.5-11.3 oz. per 1,000 ft. of row for any row spacing larger than 32-inches. Use at planting or postemergence. Heavy or clay soils: 13.0-17.3 oz. per 1,000 ft. of row. Do not use post emergence. Apply as a band application on each side of row and beneath soil surfaces, or in the seed furrow. REI: 48-hour. PHI: 90-day. *RUP*.

**Voliam Flexi® (thiamethoxam, chlorantraniliprole)** 4 oz. per acre. Do not exceed 8 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 14-day.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

## Leafhoppers

**Actara® (thiamethoxam)** 1.5-3.0 oz. per acre. Do not exceed 6 oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: 14-day.

**Admire Pro® (imidacloprid)** Seed piece treatment: 0.17-0.35 fl. oz. per 100 lbs. of seed applied directly to seed pieces. Soil application: 5.7-8.7 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. Do not exceed 8.7 fl. oz. per acre per season

from seed or soil applications. Foliar application: 1.3 fl. oz. per acre applied to foliage. Do not exceed 5.6 fl. oz. per acre per season from foliar applications. See pollinator precautions. REI: 12-hour. PHI: 7-day for foliar applications.

**Ambush® (permethrin)** 3.2-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. REI: 12-hour. RUP.

**Asana XL® (esfenvalerate)** 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. RUP.

**Assail 30SG® (acetamiprid)** 1.5-4.0 oz. per acre. Do not exceed 4 applications per year, or 16 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Athena® (bifenthrin, abamectin)** 7-17 fl. oz. per acre. Do not exceed 42 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. RUP.

**Baythroid XL® (beta-cyfluthrin)** 0.8-1.6 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. RUP.

**Belay® (clothianidin)** Seed piece treatment: 0.4-0.6 fl. oz. per 100 lbs. of seed applied directly to seed pieces. Soil application: 9-12 fl. oz. per acre applied in-furrow, side-dressed, or below seed piece at planting. Do not exceed 12 fl. oz. per acre per season from seed or soil applications. Foliar application: 2-3 fl. oz. per acre applied to foliage. Do not exceed 12 fl. oz. per acre per season from foliar applications. Allow 7 days between applications. See pollinator precautions. REI: 12-hour. PHI: 14-day.

**Dimethoate 4E® (dimethoate)** 0.5-1.0 pt. per acre. Do not exceed 2 pts. per acre per season. Allow 7 days between application. REI: 48-hour. PHI: 0-day.

**Endigo ZC® (thiamethoxam, lambda-cyhalothrin)** 3.5-4.5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. Allow 7 days between applications. REI: 24-hour. PHI: 14-day. RUP.

**Lannate LV® (methomyl)** 1.5-3.0 pts. per acre. Do not exceed 15 pts. per acre per season. REI: 48-hour. PHI: 6-day. RUP.

**malathion formulations (malathion)** Use the following rates for different formulations. 5 formulations: 1 pt. per acre. 5E formulations: 2 pts. per acre. 57EC formulations: 1-1.5 pts. per acre. PHI: 0-day.

**Mustang Maxx® (zeta-cypermethrin)** 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 4 days between applications. REI: 12-hour. PHI: 1-day. RUP.

**Platinum 2SC® (thiamethoxam)** 5-8 fl. oz. per acre.

Apply as in-furrow spray during planting, as a directed spray to base of plant at emergence, as a broadcast spray during last hilling operation, or as an overhead chemigation after last hilling. Do not exceed 8 fl. oz. per acre per season. Make only one application per season. REI: 12-hour. PHI: NA

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 6.4 lbs. per acre per season. Allow 10 days between applications. REI: 12-hour. PHI: 14-day. RUP.

**Scorpion 35SL® (dinotefuran)** Soil application: 11.5-13.25 fl. oz. per acre applied in-furrow at planting, or side-dressed to both sides of the row at ground crack. Do not exceed 13.25 fl. oz. per acre per season from seed or soil applications. Foliar application: 2.0-2.75 fl. oz. per acre applied to foliage. Do not exceed 8.0 fl. oz. per acre per season from foliar applications. Allow 14 days between applications. See pollinator precautions. REI: 12-hour. PHI: 7-day.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** See label. Rates vary by product. Choose seed treatments that include thiamethoxam insecticide (Cruiser 5FS®, Cruiser Maxx®, and Cruiser Maxx Potato®). For best results, plant potatoes immediately after treatment. PHI: See label.

**Sevin XLR Plus® (carbaryl)** 0.5-1.0 qts. per acre. Do not exceed 6 qts. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 7-day.

**Sivanto 200SL® (flupyradifurone)** 7.0-10.5 fl. oz. per acre. Do not exceed 28.0 fl. oz. per acre per season. Allow 7 days between applications. REI: 4-hour. PHI: 7-day.

**Thimet 20G® (phorate)** Light or sandy soils: 8.5-11.3 oz. per 1,000 ft. of row for any row spacing larger than 32-inches. Use at planting or postemergence. Heavy or clay soils: 13.0-17.3 oz. per 1,000 ft. of row. Do not use post emergence. Apply as a band application on each side of row and beneath soil surfaces, or in the seed furrow. REI: 48-hour. PHI: 90-day. RUP.

**Torac 15EC® (tolfenpyrad)** 14-21 fl. oz. per acre.

Do not exceed 42 fl. oz. per acre per season, or 2 applications. Allow 14 days between applications. See pollination precautions. REI: 12-hour. PHI: 14-day.

**Transform WG® (sulfoxaflor)** 1.5-2.25 oz. per acre. Do not exceed 8.5 oz. per acre per season. Allow 14 days between applications. REI: 24-hour. PHI: 7-day.

**Voliam Flexi® (thiamethoxam, chlorantraniliprole)** 4 oz. per acre. Do not exceed 8 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 14-day.

**Vydate C-LV® (oxamyl)** 17-34 fl. oz. per acre. Do not exceed 306 fl. oz. per acre per season, or 8 applications per crop. Allow 14 days between applications. In Kansas do not exceed 204 fl. oz. per acre per season, or 4 applications per crop. Allow 14 days between applications. REI: 48-hour. PHI: 7-day. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 0.96-1.60 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

### **Wireworms**

**Admire Pro® (imidacloprid)** 0.17-0.35 fl. oz. per 100 lbs. of seed. Apply directly to seed pieces. Do not exceed 8.7 fl. oz. per acre per season. See pollinator precautions. REI: 12-hour. PHI: NA

**Brigade 2EC® (bifenthrin)** 9.6-19.2 fl. oz. per acre. Apply as preplant broadcast and incorporate, at planting as a banded spray into furrow, or at lay-by as a soil-directed and incorporated spray through cultivation. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. *RUP*.

**Capture LFR® (bifenthrin)** 12.75-25.5 fl. oz. per acre. Apply as preplant broadcast and incorporate, at planting as a banded spray into furrow, or at lay-by as a soil-directed and incorporated spray through cultivation. REI: 12-hour. PHI: 21-day. *RUP*.

**Diazinon AG500® (diazinon)** 3-4 qts. per acre. Ohio only - applicators must have a 24(c) label. Preplant broadcast and incorporate into top 4-8 inches of soil. PHI: 3-day. *RUP*.

**Platinum 2SC® (thiamethoxam)** 5-8 fl. oz. per acre. Apply as in-furrow spray during planting, as a directed spray to base of plant at emergence, as a broadcast spray during last hilling operation, or as an overhead chemigation after last hilling. Do not exceed 8 fl. oz. per acre per season. Make only one application per season. REI: 12-hour. PHI: NA

**Regent 4SC® (fipronil)** 0.184-0.220 fl. oz. per 1,000 ft. of row. Do not apply in row spacing less than 30 inches. On any row spacing greater than 36 inches, apply no more than 0.220 fl. oz. REI: 0-hour. PHI: 90-day. *RUP*.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** See label. Rates vary by product. Choose seed treatments that include thiamethoxam insecticide (Cruiser 5FS®, Cruiser Maxx®, and Cruiser Maxx Potato®). For best results, plant potatoes immediately after treatment. PHI: See label.

**Thimet 20G® (phorate)** Light or sandy soils: 8.5-11.3 oz. per 1,000 ft. of row for any row spacing larger than 32-inches. Use at planting or postemergence. Heavy or clay soils: 13.0-17.3 oz. per 1,000 ft. of row. Do not use post emergence. Apply as a band application on each side of row and beneath soil surfaces, or in the seed furrow. REI: 48-hour. PHI: 90-day. *RUP*.

# Rhubarb

## Varieties

McDonald, Sutton, Valentine (produces fewer seed stalks than McDonald) — all red-fleshed varieties.

## Planting and Spacing

**Crowns:** Use only young, healthy crowns having preferably 2 or 3 buds. Rows 5 to 6 feet apart. Set crowns in rows 3 feet apart in shallow furrows so crowns will be 2 inches below surface.

## Age for Harvesting

Harvest no longer than 4 weeks, beginning with the third season of growth. Harvest for about 8 to 10 weeks after the third season. Do not remove more than two-thirds of the developed stalks from any plant at one time.

## Bolting (Seed Stalk Formation)

Infertile soil, extreme heat or cold, drought, or long days that expose plants to too much light may cause bolting. Old plants bolt more. Valentine is more sensitive than McDonald, Ruby, and most green-stalked varieties.

## Fertilizing

**Lime:** To maintain a soil pH of 6.2 to 6.8.

**Preplant:** N: 50 pounds per acre.  $P_2O_5$ : 0 to 150 pounds per acre.  $K_2O$ : 0 to 200 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. Apply 25 additional pounds of  $P_2O_5$  directly in furrows when setting the rootstalks (divided crowns).

**Yearly:** Only N needed. Broadcast 50 pounds N per acre before beds are worked in the spring. Topdress with 35 pounds N per acre after new growth resumes.

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### *Crown and Root Rot of Rhubarb - Phytophthora Oomycete*

Use disease-free plants. Plant only on well-drained soil.

**Land selection** Plant only on well-drained soil.

**Sanitation** Use disease-free plants.

#### *Leaf Spot of Rhubarb - Ascochyta Fungus*

Fertilize in the fall for growth in the spring. Remove older, yellowed leaves or leaves with lesions in the fall.

**Optimize fertilization** Fertilize in the fall for growth in the spring. Improves rapid, strong plant growth and uniform establishment. Enhances competitiveness.

**Sanitation** Remove older yellowed leaves or leaves with lesions in the fall.

## Weed Control

### Recommended Controls

Before spring growth, harrow bed thoroughly but carefully to avoid injuring the crowns. During the growing season, cultivate row-middles and hand hoe to keep the planting clean. Following the first light freeze in fall, mulch with 3-4 inches of straw around plants, but not on crowns. If additional mulch is needed in the spring, apply before hot, dry weather. Add more mulch during summer (if needed) to control weeds and retain moisture.

The herbicides listed below may also be used. Herbicides that control broadleaves must be applied while rhubarb is dormant or with shielded equipment between the row, as stated on the label. Herbicides that kill only emerged grasses may be applied over the top of rhubarb plants.

For specific weeds controlled by each herbicide, check Relative Effectiveness of Herbicides for Vegetable Crops in the printed guide.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

## **Burndown or Directed/Shielded Application**

### **Broadleaf and Grass Weeds**

**glyphosate formulations (glyphosate)** 0.75-3.75 lb. acid equivalent (ae) per acre. Use formulations containing 3 lb. ae per gal. (4 lb. isopropylamine salt per gal.) at 1-5 qt. per acre, or formulations containing 4.5 lb. ae per gal. (5 lb. potassium salt per gal.) at 0.66-3.3 qt. per acre. Broadcast before plants emerge, or apply between rows with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. REI: 4-hour. PHI: 14-day.

**paraquat formulations (paraquat)** 2.5-4 pt. per acre of 2 lb. per gal. formulation or 1.7-2.7 pt. per acre of 3 lb. per gal. formulation. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS (0.25%) to 25 gal. of solution. Apply during the dormant season before buds begin to grow. Do not exceed 2 applications per year. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 24-hour. *RUP*.

## **Burndown or Directed/Shielded Application**

### **Broadleaf and Grass Weeds**

**Aim EC® (carfentrazone)** 0.5-2.0 fl. oz. per acre. Apply a minimum of 1 day prior to transplanting, or apply between crop rows with hooded sprayer. Do not allow spray to contact crop. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Weeds must be actively growing and less than 4 in. tall. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day.

## **Preemergence Broadleaf and Grass Weeds**

**Caparol 4L® (prometryn)** 2-4 pt. per acre. Apply to dormant, established rhubarb before leaves emerge in spring. Use low rate on light soils. If weeds are present, add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). REI: 12-hour. PHI: 40-day.

**Casoron 4G® (dichlobenil)** 50 lb. per acre. Apply before rhubarb emerges in early spring. Broadcast on soil, and thoroughly incorporate granules by watering in. REI: 12-hour.

**Command 3ME® (clomazone)** 2 qt. per acre. Apply to dormant rhubarb prior to leaf emergence. Do not make more than one application per crop per year. REI: 12-hour.

**Dual Magnum® (s-metolachlor)** 0.67-1.33 pt. per acre.

Apply in spring before rhubarb and weeds emerge. Do not exceed one application and 1.33 pts. per acre per year. REI: 24-hour. PHI: 62-day.

**Kerb SC® (pronamide)** 2.5-5 pt. per acre. Michigan

only: Apply to dormant plants after frost has killed leaves in fall. Suppresses quackgrass. Do not apply to rhubarb the year of planting. Include glyphosate with application for better weed control. REI: 24-hour. PHI: 38-day. *RUP*.

**Lorox DF® (linuron)** 2-3 lb. per acre. Apply broadcast to dormant rhubarb in the spring before leaves emerge. REI: see label.

## **Preemergence Broadleaf Weeds**

**Callisto® (mesotrione)** 6 fl. oz. per acre. Apply to dormant, established rhubarb. Applying after growth begins will cause crop stunting and bleaching. If weeds are emerged, add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Has residual activity to control weeds that have not emerged. Do not exceed 6 fl. oz. per acre per year, or 1 application per year. REI: 12-hour. PHI: 21-day.

**Sandea® (halosulfuron)** 0.5-1.0 oz. per acre. Apply to dormant rhubarb in the spring. If weeds are present, add 0.5 pt. NIS per 25 gal. of solution (0.25% v/v). May cause crop stunting. Use low rate to determine crop safety under field conditions. Controls yellow nutsedge. Does not control grass. REI: 12-hour. PHI: 60-day.

## **Postemergence Broadleaf and Grass Weeds**

**Caparol 4L® (prometryn)** See recommendations in the "Preemergence Broadleaf and Grass Weeds" section of this chapter.

**QuinStar 4L® (quinclorac)** 12.6 fl. oz. per acre. Apply as a foliar spray to control Canada thistle and field bindweed. Can make a second application 30 days after the first. Do not exceed 25.2 fl. oz. per acre per year. REI: 12-hour. PHI: 30-day.

**Sandea® (halosulfuron)** See recommendations in the Preemergence Broadleaf Weeds section of this chapter.

## Postemergence Grass Weeds

**clethodim formulations (clethodim)** Use 2 lb. per gal. formulations at 6-8 fl. oz. per acre with 1 qt. COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season. Use 0.97 lb. per gal. formulations at 9-16 fl. oz. per acre with 8 fl. oz. NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max per acre per season. Use low rates for annual grasses and high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 30-day.

**Fusilade DX® (fluazifop-P)** 10-16 fl. oz. per acre. Add 1 qt. COC (1% v/v) or 0.5 NIS per 25 gal. of spray solution (0.25% v/v). Apply to small actively growing grass. Do not exceed 32 fl. oz. per acre per year. REI: 12-hour. PHI: 14-day.

**Poast® (sethoxydim)** 1-1.5 pt. per acre. Add 1 qt. COC per 25 gal. of spray solution (1% v/v). Spray on actively growing grass. Do not exceed 3 pt. per acre per growing season. REI: 12-hour. PHI: 15-day in Illinois, Indiana, Michigan, and Minnesota; 30-day in other states.

## Insect Control

### Recommended Controls

#### Aphids

**Actara® (thiamethoxam)** 1.5-3.0 fl. oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** 4.4-10.5 fl. oz. per acre. Applied at soil. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 45-day.

**Assail 30SG® (acetamiprid)** 2-4 oz. per acre. Do not exceed 5 applications per season. REI: 12-hour. PHI: 7-day.

**Belay® (clothianidin)** 3-4 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Beleaf 50SG® (flonicamid)** 2-2.8 oz. per acre. REI: 12-hour. PHI: 0-day.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Fulfill® (pymetrozine)** 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Platinum 2SC® (thiamethoxam)** 5-11 fl. oz. per acre. Do not exceed 11 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Sivanto 200SL® (flupyradifurone)** 7-14 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

#### Armyworm Caterpillars

**Exirel® (cyantraniliprole)** 7.0-13.5 fl. oz. per acre.

Observe resistance management restrictions for diamondback moth. Allow 5 days between treatments. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

#### Caterpillars

**Ambush® (permethrin)** 6.4-12.8 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 12.8 fl. oz. per acre. REI: 12-hour. PHI: 1-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** 0.8-3.2 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 12.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 32 fl. oz. per acre. REI: 12-hour. PHI: 7-day. *RUP*.

**Coragen® (chlorantraniliprole)** 3.5-5.0 fl. oz. per acre. Check label for specific caterpillars. Do not exceed 15.4 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Entrust® (spinosad)** 3-8 fl. oz. per acre. For loopers and armyworms. Do not exceed 29 fl. oz. per acre per season. Observe resistance management restrictions. REI: 4-hour. PHI: 1-day. *OMRI-listed*.

**Exirel® (cyantraniliprole)** 7-17 fl. oz. per acre. Check label for specific caterpillars. Observe resistance management restrictions for diamondback moth. Allow 5 days between treatments. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Intrepid 2F® (methoxyfenozide)** 4-10 fl. oz. per acre. For loopers and armyworms. Do not exceed 64 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-4.0 fl. oz. per acre. For earworms, cutworms, loopers, and armyworms. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Pounce 25WP® (permethrin)** 3.2-12.8 oz. per acre. For earworms, corn borers, cutworms, loopers, and armyworms. Do not exceed 4 lbs. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Radiant 1SC® (spinetoram)** 5-10 fl. oz. per acre. For earworms, loopers, and armyworms. Do not exceed 34 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Sevin XLR Plus® (carbaryl)** 1-2 qts. per acre. For earworms, cutworms, loopers, and armyworms. Do not exceed 6 qts. per acre per season. REI: 12-hour. PHI: 14-day.

### **Common Stalk Borer Caterpillar**

There are no registered insecticides that will give adequate control.

Control by cultivating field and margins. Remove curly dock, the normal host for rhubarb curculios.

### **Cultivate field and margins**

**Remove curly dock** Curly dock is the normal host for rhubarb curculios.

### **Corn Earworm/Fruitworm Caterpillar**

**Exirel® (cyantraniliprole)** 7.0-13.5 fl. oz. per acre. Observe resistance management restrictions for diamondback moth. Allow 5 days between treatments. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

### **Diamondback Moth Caterpillar**

**Exirel® (cyantraniliprole)** 7.0-13.5 fl. oz. per acre. Observe resistance management restrictions for diamondback moth. Allow 5 days between treatments. Do not exceed 61.7 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day.

### **Leafhoppers**

**Actara® (thiamethoxam)** 1.5-3.0 fl. oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** 4.4-10.5 fl. oz. per acre. Applied at soil. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 45-day.

**Assail 30SG® (acetamiprid)** 2-4 oz. per acre. Do not exceed 5 applications per season. REI: 12-hour. PHI: 7-day.

**Belay® (clothianidin)** 3-4 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Platinum 2SC® (thiamethoxam)** 5-11 fl. oz. per acre. Do not exceed 11 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Sivanto 200SL (flupyradifurone)** 7-14 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

### **Whiteflies**

**Actara® (thiamethoxam)** 3.0-5.5 oz. per acre. Do not exceed 11 oz. per acre. per season. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** 4.4-10.5 fl. oz. per acre. Applied at soil. Do not exceed 10.5 fl. oz. per acre per season. REI: 12-hour. PHI: 45-day.

**Assail 30SG® (acetamiprid)** 2-4 oz. per acre. Do not exceed 5 applications per season. REI: 12-hour. PHI: 7-day.

**Belay® (clothianidin)** 3-4 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Fulfill® (pyrethroid)** 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. REI: 12-hour. PHI: 1-day.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Platinum 2SC® (thiamethoxam)** 5-11 fl. oz. per acre. Do not exceed 11 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day.

**Sivanto 200SL® (flupyradifurone)** 7-14 fl. oz. per acre. REI: 4-hour. PHI: 1-day.

# Root Crops

## Beet, Carrot, Parsnip, Radish, Rutabaga, and Turnip

### Spacing

**Beets:** Rows 18 to 24 inches apart. Seed 8 to 10 pounds per acre for bunching.

**Carrots:** Rows 16 to 30 inches apart. Plant 20 to 30 per foot for slicing/fresh market; 10 to 20 plants per foot for dicing.

**Parsnips:** Rows 18 to 24 inches apart. Seed 2 to 3 pounds per acre.

**Radishes:** Rows 15 inches apart. Plant 12 to 15 per foot of row. Seed 10 to 15 pounds per acre.

**Turnips:** Rows 14 to 18 inches apart. Plant 2 to 3 inches apart in row. Seed 1 to 2 pounds per acre.

### Fertilizing

**Lime:** To maintain a soil pH of 6.0 to 6.8; for beets, 6.5 to 7.0.

**Preplant:** N: 60 pounds per acre.  $P_2O_5$ : 20 to 160 pounds per acre.  $K_2O$ : 0 to 200 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. If soil tests indicate that a high amount of K is necessary, plow down at least half the requirement. Beets also respond to boron when grown on sandy soils, light-colored silt and clay loams, and alkaline, dark-colored soils. Boron may be omitted on acid, dark-colored soils. Based on a boron soil test, include boron at 2 1/2 to 5 pounds per acre applied over the row at planting. Do not contact with seed. Boron is toxic to many vegetables, particularly beans, peas, and cucurbits. Thus, rotational plans may have to be adjusted. For carrots grown on muck soil with a soil pH greater than 6.0, add 6 pounds of manganese per acre.

### Sidedress N

**Beets, carrots, parsnips:** for soils with more than 3 percent organic matter and following soybeans, alfalfa or a grass-legume hay crop, apply 30 pounds N per acre 4 to 6 weeks after planting. For soils with less than 3 percent organic matter and the above rotation, apply 45 pounds N per acre. Following corn, rye, oats, wheat, or a vegetable crop, apply 60 pounds N per acre.

**Radish, turnip:** none needed.

### Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

### Disease Control

#### Recommended Controls

##### **Cavity Spot of Carrots - Pythium Fungus**

Cavity spot can affect root quality and yield.

**Presidio® (fluopicolide)** *Carrot* 4 fl. oz. per acre. Labeled for in-furrow applications. Use 5-10 gallons of water per acre. REI: 12-hour. PHI: 7-day

**Ranman 400SC® (cyazofamid)** *Carrot* 6 fl. oz. per acre. REI: 12-hour. PHI: 14-day PHI.

**Reason 500SC® (fenamidone)** *Carrot* 8.2 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Ridomil Gold Bravo SC® (mefenoxam, chlorothalonil)** *Carrot* 1.5-2.5 pts. per acre. REI: 48-hour. PHI: 7-day.

**Ridomil Gold SL® (mefenoxam)** *Carrot* See application notes. Preplant incorporation or soil spray: 0.5-1.3 pts. per acre. Postplant chemigation, shanked in, or directed spray: 0.25-1 pt. per acre. REI: 48-hour. PHI: 7-day.

**Ultra Flourish® (mefenoxam)** *Carrot* See application notes Preplant incorporation or soil spray: 1-2.6 pts. per acre. Postplant chemigation, shanked in, or directed spray: 0.5-2 pts. per acre. REI: 48-hour. PHI: 7-day.

##### **Damping-Off Seed and Seedling Rots of Multiple Crops - Multiple Pathogens**

Conditions that favor rapid seedling germination may limit damping-off severity. Avoid excessive irrigation and poorly drained soils.

**Presidio® (fluopicolide)** *Beet, Parsnip, Radish, Turnip* 3-4 fl. oz. per acre. Pythium damping-off only. REI: 12-hour. PHI: 7-day.

**Quadris 2.08SC® (azoxystrobin)** *Beet, Parsnip, Radish, Turnip* 0.4-0.8 fl. oz. per 1,000 row-feet. REI: 4-hour. PHI: 0-day.

**Reason 500SC® (fenamidone)** *Beet, Parsnip, Radish, Turnip* 8.2 fl. oz. per acre. Pythium damping-off only. REI: 12-hour. PHI: 14-day.

**Uniform® (mefenoxam, azoxystrobin)** *Beet, Parsnip, Radish, Turnip* 0.34 fl. oz. per acre per 1,000 ft. of row. Make one application per crop season. REI: 0-hour. PHI: NA

### **Leaf Blight of Carrots - *Xanthomonas* Bacteria**

Copper products that are labeled for Cercospora may be helpful; however, bacteria may become resistant to copper products. Early bacterial leaf blight symptoms may mimic Alternaria leaf spot.

Bacteria may occur on seed and can survive on carrot debris in soil. Bacteria spread within a field by rain or overhead irrigation. Under dry conditions, low levels of bacterial leaf blight may not result in significant crop loss. Under hot and wet conditions, high levels of bacterial blight may develop and lead to premature defoliation and an inability to harvest the roots via a mechanical harvester. Work under blighted fields as soon as the crop is harvested so the infected foliage can decompose rapidly, which will reduce the survival of the bacteria in the soil.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)**

*Carrot* Copper products labeled for Cercospora may provide some control. REI: see label.

### **Leaf Blight of Root Crops - *Alternaria* Fungus**

Practice a 3-4 year crop rotation. Scout fields to initiate a spray program when foliar blights are first detected (trace of disease). TOM-CAST with 15 disease severity values (DSVs) can help carrot farmers time their fungicide applications for control of foliar blights. See Disease Forecasting Systems for details. Cercospora leaf spot is sometimes known as early blight. Alternaria leaf blight is sometimes known as late blight.

**azoxystrobin formulations (azoxystrobin)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip* 6-15.5 fl. oz. per acre. Alternaria (late blight) diseases only. REI: 4-hour. PHI: 0-day.

**Cabrio EG® (pyraclostrobin)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip* 8-12 oz. per acre. REI: 12-hour. PHI: 0-day

**chlorothalonil formulations (chlorothalonil)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip* See label. REI: 12-hour.

**Endura® (boscalid)** *Carrot* 4.5 oz. per acre. REI: 12-hour. PHI: 0-day.

**Flint® (trifloxystrobin)** *Beet, Carrot, Parsnip, Turnip* 2-3 oz. per acre. Carrot, beet, Parsnip and turnip only. REI: 12-hour. PHI: 7-day.

**Fontelis® (penthiopyrad)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip* 16-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day.

**Gem 500SC® (trifloxystrobin)** *Beet, Carrot, Parsnip, Turnip* 1.9-2.9 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**iprodione formulations (iprodione)** *Carrot* 1-2 pts. per acre. Iprodione 4L AG®, Rovral 4 Flowable®, and Meteor® are some formulations. REI: 24-hour. PHI: 0-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** *Carrot* 4-7.6 fl. oz. per acre. Alternaria leaf blight on carrot only. REI: 12-hour. PHI: 7-day.

**Luna Sensation® (fluopyram, trifloxystrobin)** *Parsnip, Radish, Turnip* 5-5.8 fl. oz. per acre. Alternaria leaf blight of parsnip, radish, turnip only. REI: 12-hour. PHI: 7-day.

**Luna Tranquility® (fluopyram, pyrimethanil)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip* 8-11.2 fl. oz. per acre. REI: 12-hour. PHI: 7-day

**Merivon® (fluxapyroxad, pyraclostrobin)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip* 4-5.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Omega 500F® (fluazinam)** *Carrot* 1 pt. per acre. Alternaria (late blight) on carrot only. REI: see label. PHI: 7-day.

**Pristine 38WG® (boscalid, pyraclostrobin)** *Carrot* 8-10.5 oz. per acre. REI: 12-hour. PHI: 0-day.

**Propimax EC® (propiconazole)** *Carrot* 4 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Quadris Opti® (azoxystrobin, chlorothalonil)** *Carrot* 2.4 pts. per acre. Carrot only. REI: 12-hour. PHI: 0-day.

**Quadris Top® (azoxystrobin, difenoconazole)** *Carrot* 12-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Quilt® (azoxystrobin, propiconazole)** *Carrot* 14 oz. per acre. Carrot only. REI: 12-hour. PHI: 14-day.

**Quilt Xcel® (azoxystrobin, propiconazole)** *Carrot* 14 fl. oz. per acre. Carrot only. REI: 12-hour. PHI: 14-day.

**Switch 62.5WG® (cyprodinil, fludioxonil)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip* 11-14 oz. per acre. Do not exceed 2 applications to radish. REI: 12-hour. PHI: 7-day.

**tebuconazole formulations (tebuconazole)** *Beet 3-7.2 fl. oz. per acre. Tebuconazole formulations include Monsoon®, Onset 3.6L®, Orious 3.6F®, Tebuzol 3.6F®. REI: see label. PHI: 7-day.*

**Tilt® (propiconazole)** *Carrot 4 fl. oz. per acre. Alternaria (late blight) on carrot only. REI: 12-hour. PHI: 14-day.*

### **Leaf Spot of Radish - Septoria Fungus**

Practice a 3-year crop rotation. Plow residue as soon as possible after harvest. Avoid volunteer plants and cruciferous weeds.

**Crop rotation** *Radish* Rotate between crop families to reduce disease inoculum buildup.

### **Leaf Spot of Root Crops - Cercospora Fungus**

Practice a 3-4 year crop rotation. Scout fields to initiate a spray program when foliar blights are first detected (trace of disease). TOM-CAST with 15 disease severity values (DSVs) can help carrot farmers time their fungicide applications for control of foliar blights. See Disease Forecasting Systems for details. Cercospora leaf spot is sometimes known as early blight. Alternaria leaf blight is sometimes known as late blight.

**azoxystrobin formulations (azoxystrobin)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip 6-15.5 fl. oz. per acre. Alternaria (late blight) diseases only. REI: 4-hour. PHI: 0-day.*

**azoxystrobin formulations (azoxystrobin)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip 9-15.5 fl. oz. per acre. Cercospora (early blight) diseases only. REI: 4-hour. PHI: 0-day.*

**Cabrio EG® (pyraclostrobin)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip 8-12 oz. per acre. REI: 12-hour. PHI: 0-day*

**chlorothalonil formulations (chlorothalonil)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip* See label. REI: 12-hour.

**copper formulations (copper hydroxide, copper octanoate, copper oxychloride, copper sulfate, copper diammonium diacetate complex, cuprous oxide)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip* REI: see label.

**Flint® (trifloxystrobin)** *Beet, Carrot, Parsnip, Turnip 2-3 oz. per acre. Carrot, beet, Parsnip and turnip only. REI: 12-hour. PHI: 7-day.*

**Fontelis® (pentiopyrad)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip 16-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day.*

**Gem 500SC® (trifloxystrobin)** *Beet, Carrot, Parsnip, Turnip 1.9-2.9 fl. oz. per acre. REI: 12-hour. PHI: 7-day.*

**Merivon® (fluxapyroxad, pyraclostrobin)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip 5.5 fl. oz. per acre. REI: 12-hour. PHI: 7-day.*

**Quadris Opti® (azoxystrobin, chlorothalonil)** *Carrot 2.4 pts. per acre. Carrot only. REI: 12-hour. PHI: 0-day.*

**Quadris Top® (azoxystrobin, difenoconazole)** *Carrot 12-14 fl. oz. per acre. REI: 12-hour. PHI: 7-day.*

**Quilt® (azoxystrobin, propiconazole)** *Carrot 14 oz. per acre. Carrot only. REI: 12-hour. PHI: 14-day.*

**Quilt Xcel® (azoxystrobin, propiconazole)** *Carrot 14 fl. oz. per acre. Carrot only. REI: 12-hour. PHI: 14-day.*

**tebuconazole formulations (tebuconazole)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip 4-7.2 fl. oz. per acre. Turnip only. REI: see label. PHI: 7-day.*

### **White Mold (Timber Rot) of Multiple Crops - Sclerotinia Fungus**

Practice a 3-year crop rotation. Avoid rotating with beans, cucurbits, and late cabbage.

**Endura® (boscalid)** *Carrot 7.8 oz. per acre. Carrot only. REI: 12-hour. PHI: 0-day.*

**Fontelis® (pentiopyrad)** *Beet, Carrot, Radish, Turnip 16-30 fl. oz. per acre. REI: 12-hour. PHI: 0-day.*

**Luna Sensation® (fluopyram, trifloxystrobin)** *Beet, Parsnip, Radish, Turnip 5.8 fl. oz. per acre. REI: 12-hour. PHI: 7-day.*

**Luna Sensation® (fluopyram, trifloxystrobin)** *Carrot 7.6 fl. oz. per acre. REI: 12-hour. PHI: 7-day.*

**Luna Tranquility® (fluopyram, pyrimethanil)** *Beet, Carrot, Parsnip, Radish, Rutabaga, Turnip 11.2 fl. oz. per acre. REI: 12-hour. PHI: 7-day.*

**Omega 500F® (fluazinam)** *Carrot 1 pt. per acre. REI: see label. PHI: 7-day.*

### **White Rust of Brassicas - Albugo Fungus**

**Cabrio EG® (pyraclostrobin)** *Radish, Turnip 8-16 oz. per acre. REI: 12-hour. PHI: 0-day.*

**Ridomil Gold Copper® (mefenoxam, copper hydroxide)** *Radish 1-2 lbs. per acre. Use as a foliar spray. REI: 48-hour. PHI: 7-day.*

## Weed Control

Cultivation and hand hoeing are usually important components of weed control in root crops. Design bed and row spacing to match equipment that will be used. Use of a stale seedbed is helpful.

Prepare the seedbed several weeks in advance of planting, allow weeds to emerge, and kill weeds without bringing new weed seeds to the surface. This can be done with an herbicide labeled for the crop, flaming, or very shallow cultivation. It may be possible to plant without killing the weeds, and then kill them until just before the crop emerges.

If the time between seedbed preparation and planting is short, weed emergence can be sped up by putting a row cover over the soil. Weeds that emerge after seeding and before the crop can also be controlled with a labeled herbicide or flaming. For crops like carrots and parsnips that take a long time to emerge, controlling these weeds is especially useful, but it can also pay off for faster-emerging species like radishes or beets.

For specific weeds controlled by each herbicide, check Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

## Recommended Controls

### Burndown or Directed/Shielded Applications

#### Broadleaf and Grass Weeds

glyphosate formulations (glyphosate) *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qt. per acre. Broadcast before seeding, or apply between crop rows with wipers or hooded or shielded sprayers. Use lower rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. For carrot and rutabaga only wipers may be used over top of crop, see label. REI: 4-hour. PHI: 14-day for applications directed between rows, 7-day for wiper applications on carrot only.

#### Gramoxone SL 2.0® (paraquat) *Carrot, Turnip* 2-4 pts.

per acre. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before or after seeding but before crop emerges. REI: see label. RUP.

### Preemergence Broadleaf and Grass Weeds

#### Dual Magnum® (s-metolachlor)

*Carrot* 0.5-2.0 pts. per acre. Illinois, Indiana, Michigan, Minnesota, and Ohio only — applicators must have 24c label. Illinois label expires December 31, 2024. Michigan and Ohio labels expire December 31, 2021. Minnesota label expires Dec 31, 2022. Apply as broadcast after planting but before carrots emerge at 0.5-1.0 pt. per acre on mineral soils or 1.33-2.0 pts. per acre on muck soils. Or, apply as a postemergence broadcast application after carrots have 3-5 true leaves for residual control of weeds at 0.67-1.33 pt. per acre on mineral soils or 1.33-2.0 pts. per acre on muck soils. Do not apply both pre and postemergence. Only the postemergence application is allowed in Ohio. REI: 24-hour. PHI: 64-day.

*Beet, radish, and turnip root in Illinois, Indiana, Michigan and Ohio only; Parsnip and Rutabaga in Illinois, Indiana, and Michigan only.* Applicators must have 24c label. 0.67-1 pt. per acre on mineral soils, or up to 1.3 pts. per acre on muck soils. Apply before planting with or without incorporation, or apply after seeding before crop emerges. Risk of crop injury is generally greater with preplant incorporated applications than with preplant or preemergence applications. Risk of crop injury is greater on coarse-textured soils with less than 1.5% organic matter. Do not exceed 1.3 pts. per acre per crop or 1 application per crop. REI: 24-hour.

*Horseradish:* 1.0-1.33 pts. per acre. Apply after planting and before weeds emerge. Do not apply more than once per crop. REI: 24-hour.

#### Lorox DF® (linuron)

*Carrot* In Minnesota only, apply 1-2 lbs. per acre after planting but before carrots emerge. In Michigan and Ohio only, apply 1-3 lbs. per acre per acre after planting but before carrots emerge. Use low rate on coarse soils and higher rate on heavy soils and muck. Do not use on sand, loamy sand, or soils with less than 1% organic matter. In all states, apply 1.5-3 lbs. per acre as a broadcast spray after carrots are over 3 inches

tall. Will provide some residual control of non-emerged weeds. Do not apply if temperature is over 85 F. Repeat applications are allowed but must not exceed 4 lbs. per acre per season. REI: see label. PHI: 14-day.

**Celeriac** 1.5-3.0 lbs. per acre. Make a single application as a broadcast spray after celeriac has been transplanted and established, but before celeriac is 8 inches tall. Use low rate on coarse soils and higher rate on heavy soils and muck. Do not use on sand, loamy sand, or soils with less than 1% organic matter. Do not add surfactants, nitrogen (or other fertilizers), or other pesticides to the spray mix. REI: see label. PHI: 60-day.

**Horseradish** 1-3.0 lbs. per acre. Make a single application as a broadcast spray after planting or during dormancy, but before leaves emerge in spring. After planting irrigate before applying if it does not rain. Use lower rate on coarse soils and higher rate on heavy soils. Do not use on sand, loamy sand, or soils with less than 1% organic matter. REI: see label.

**Parsnip** 1.5-3.0 lbs. per acre. Make a single application as a broadcast spray after parsnip has been planted, but before emergence. Plant at least 0.5 inch deep. Use low rate on coarse soils and higher rate on heavy soils and muck. Do not use on sand, loamy sand, or soils with less than 1% organic matter. REI: see label.

**Nortron SC® (ethofumesate)** *Beet* Preemergence: 60 fl. oz. per acre. Apply at (or soon after) seeding, and before weeds germinate. Early postemergence: 5.25 fl. oz. per acre. Apply when beets have 2-4 true leaves. Postemergence: 10.5 fl. oz. per acre. Apply when beets have 6-8 true leaves. May cause temporary leaf fusion. May injure stressed plants. Use on mineral soils only. Do not exceed 96 fl. oz. per acre per season. REI: 12-hour.

**Outlook® (dimethenamid-p)** *Horseradish* 12-21 fl. oz. per acre. Apply from 2-leaf stage to 8-leaf stage of horseradish. Cold, wet conditions at application may stunt horseradish. Will not control emerged weeds. REI: 12-hour. PHI: 40-day.

**Prowl H2O® (pendimethalin)** *Carrot* 2 pts. per acre. Apply within 2 days after seeding and before crop and weeds emerge. Or apply at layby as a directed spray between rows. Do not allow spray to contact carrot plants. Will not control emerged weeds. Do not exceed 2 pts. per acre per season. REI: 24-hour. PHI: 60-day.

### **trifluralin formulations (trifluralin)** *Carrot, Radish*

0.5-0.75 lb. a.i. per acre. Use 4EC formulations at 1-1.5 pts. per acre. Use 10G formulations at 5-7.5 lbs. per acre. Apply and incorporate 1-2 inches before planting. Use low rate on coarse soils with less than 2% organic matter. Not effective on muck or high organic matter soils. REI: 12-hour.

### **Preemergence Broadleaf Weeds**

#### **Caparol 4L® (prometryn)**

*Carrot* 1-2 pts. per acre. May stunt carrot. Use lowest rate on sandy soils. Do not apply after carrots have 6 leaves. Do not exceed 8 pts. per acre per year. REI: 12-hour. PHI: 30-day.

**Celeriac** 1.6-4 pts. per acre. Apply after transplanting after crop has 6-8 leaves. Use low rate on light soils. REI: 12-hour. PHI: 60-day.

**GoalTender® (oxyfluorfen)** *Horseradish* 1 pt. per acre for GoalTender 4SC®, or 2 pts. per acre for Goal 2XL®. Apply after planting prior to crop emergence. REI: see label.

**Spartan 4F® (sulfentrazone)** *Horseradish* Spartan 4F® at 2.25-8.0 fl. oz. per acre., or **Spartan Charge® (sulfentrazone and carfentrazone)** at 2.9-10.2 fl. oz. per acre. Spartan Charge® has postemergence contact activity. Broadcast in the spring before planting or after planting but at least 5 days before crop emergence; or band into row middles after crop emergence. Applications made in the spring shortly before planting may be incorporated, but do not incorporate at other times. Rainfall or irrigation is required to move herbicide into the soil when not incorporated. Do not broadcast if sprouts are close to soil surface, or over top of emerged crop. Do not use on sandy soils with less than 1% organic matter. Do not exceed 8 fl. oz. of Spartan 4F® per 12-month period. Do not exceed 10.2 fl. oz. of Spartan Charge® per 12-month period. REI: 12-hour.

### **Preemergence Grass Weeds**

**Ro-Neet® (cycloate)** *Beet* 0.5-0.67 gals. per acre. Apply before planting and incorporate immediately. Use on mineral soils only. REI: 48-hour.

### **Postemergence Broadleaf and Grass Weeds**

**glyphosate formulations (glyphosate)** See details

above for Burndown or Directed/Shielded Applications Broadleaf and Grass Weeds.

**Lorox DF® (linuron)** *Carrot, Celeriac.* See details above for Preemergence Broadleaf and Grass Weeds.

**Nortron SC® (ethofumesate)** *Beet* See details above for Preemergence Broadleaf and Grass Weeds.

**Herbicides for Root Crops: Beet, Carrot, Horseradish, Radish and Turnip<sup>1</sup>**

Products (REI/PHI)	Common Name	Timing and Application Location Relative to Crop <sup>2</sup>		Incorporated	Weed Groups Controlled	Crops <sup>3</sup>
		Relative to Weeds	Location Relative to Crop <sup>2</sup>			
Aim EC <sup>*</sup> (12h)	carfentrazone	X			X	X X X X X X X X
Caparol <sup>®</sup> (12h/30d)	prometryn	X	X		X	X X X X X X X X
Dual Magnum <sup>®</sup> (24h/variable)	s-metolachlor	X	X		X	X X X X X X X X
Goal <sup>®</sup> (12h/-)	oxyfluorfen	X			X	X X X X X X X X
Gramoxone <sup>®</sup> (12h to 24h)	paraquat	X	X		X	X X X X X X X X
Lorox 50DF <sup>®</sup> (24h/14d)	linuron	X	X		X	X X X X X X X X
Nortron SC <sup>®</sup> (12h/-)	ethofumesate	X	X		X	X X X X X X X X
Outlook <sup>®</sup> (12h/5-)	dimethenamid-P	X			X	X X X X X X X X
Roast <sup>®</sup> (12h/14d to 60d)	sethoxydim	X			X	X X X X X X X X
Prowl <sup>®</sup> (12h/60d)	pendimethalin	X	X		X	X X X X X X X X
Ro-Neet <sup>®</sup> (12h/-)	cycloate	X		Yes	X	X X X X X X X X
Roundup <sup>®</sup> , others (12h/14d)	glyphosate	X	X		X	X X X X X X X X
Select Max <sup>®</sup> , others (12h/15d to 30 d)	clethodim		X		X	X X X X X X X X
Sencor <sup>®</sup> (12h/60d)	metribuzin		X		X	X X X X X X X X
Spartan <sup>®</sup> (12h/-)	sulfentrazone	X	X		X	X X X X X X X X
Spartan Charge <sup>®</sup> (12h/-)	sulfentrazone + carfentrazone	X	X		X	X X X X X X X X
Spin-Aid <sup>®</sup> (12h/60d)	phenmedipham		X		X	X X X X X X X X
Stinger <sup>®</sup> (12h/30d)	clopyralid		X		X	X X X X X X X X
Treflan <sup>®</sup> , others (12h/-)	trifluralin	X		Yes	X	X X X X X X X X
Upbeet <sup>®</sup> , (4h/30d)	trisulfuron		X		X	X X X X X X X X

<sup>1</sup>For effectiveness against specific weeds, see Relative Effectiveness of Herbicides for Vegetable Crops (page 68), and read label. This table does not include all label information. Be sure to read and follow all instructions and precautions on the herbicide label. Herbicides can cause serious crop injury and yield loss if not used properly.

<sup>2</sup>X=permitted for at least one crop.

<sup>3</sup>X=may be used for that crop; check label for application methods permitted.

## Postemergence Broadleaf Weeds

**Aim EC® (carfentrazone)** *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* 0.5-2.0 fl. oz. per acre. Apply with hooded sprayers as a directed application between crop rows. Use COC or NIS. Weeds must be actively growing and less than 4 inches tall. Do not allow spray to contact crop. Do not exceed 6.1 fl. oz. per acre per season. REI: 12-hour.

**Caparol 4L® (prometryn)** *Carrot, Celeriac* See details above for Preemergence Broadleaf weeds.

**metribuzin formulations (metribuzin)** *Carrot* Use 0.5 pt. per acre for 4F metribuzin formulations, 0.33 lb. per acre for 75DF metribuzin formulations. Broadcast after carrots have 5-6 true leaves and when weeds are less than 1 inch tall or across. Do not apply within 3 days of cool, cloudy weather, or other pesticide application, or when temperature is above 85°F. Do not exceed 1 application per season if carrots are rotated with onions; otherwise do not exceed 1 pt. of 4F products per acre per season, or 0.66 lb. of 75DF products per acre per season. REI: 12-hour. PHI: 60-day.

**Spin-Aid® (phenmedipham)** *Beet* 1.5-3 pts. per acre in 10-20 gals. of water. Apply to beets with at least 4 true leaves to avoid injury. Do not apply if beets are stressed. Does not control pigweed. Do not exceed 3 applications. REI: 12-hour. PHI: 60-day. RUP.

**Stinger® (clopypralid)** *Beet, Turnip* 4-8 fl. oz. per acre. Apply to beets when crop has 2-8 true leaves. Controls primarily composites and nightshade. Do not exceed 8 fl. oz. per acre per crop for beet. Do not exceed 1 application per crop for turnip. REI: 12-hour. PHI: 30-day.

**UpBeet® (triflusulfuron)** *Beet* 0.5 oz. per acre. Apply postemergence when beets have 2-4 and 4-6 leaves to control velvetleaf and mustards. Suppresses lambsquarters, pigweed, nightshade, ragweed, smartweed, and wild buckwheat. Add 8 fl. oz. NIS per 25 gals. spray solution. Do not exceed 1.5 oz. per acre per season. REI: 4-hour. PHI: 30-day.

## Postemergence Grass Weeds

**clethodim formulations (clethodim)** *Beet, Carrot, Celeriac, Horseradish, Parsnip, Radish, Rutabaga, Turnip* Use 2EC formulations at 6-8 fl. oz. per acre with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Use Select Max® at 9-16 fl. oz. per acre with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Use low rates for annual grasses, the high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 32 fl. oz. of 2EC formulations or 64 fl. oz. of

Select Max per acre per season. REI: 24-hour. PHI: 15-day for radish, 30-day for other listed crops.

**Fusilade DX® (fluazifop-P)** *Carrot* 10-12 fl. oz. per acre. Use 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gals. of spray solution. Spray on actively growing grass. REI: 12-hour. PHI: 45-day.

**Poast® (sethoxydim)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 1.0-1.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 5 pts. per acre per season for beet and carrot or 2.5 pts. per acre per season for other listed crops. REI: 12-hour. PHI: 30-day for carrot, 60-day for beet, 14-day for other listed crops.

## Insect Control

### Recommended Controls

#### Aphids

**M-Pede® (potassium salts of fatty acids)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 1-2% by volume. Must contact aphids to be effective. REI: 12-hour. PHI: 0-day. OMRI-listed.

**Neemix® (azadirachtin)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 5-7 fl. oz. per acre. REI: 4-hour. PHI: 0-day. OMRI-listed.

**Actara® (thiamethoxam)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 1.5-3.0 oz. per acre. Do not exceed 4.0 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 0.31-0.74 fl. oz. per 1,000 ft. of row. Apply as chemigation through drip, as an in-furrow spray, shanked in to seed trench, or as a narrow banded spray over eventual row within 14 days of planting. REI: 12-hour. PHI: 21-day.

**Ambush® (permethrin)** *Turnip* 3.2-6.4 oz. per acre. Illinois and Indiana only. Do not exceed 8 applications per season. REI: 12-hour. PHI: 1-day. RUP.

**Beleaf 50SG® (flonicamid)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 2.0-2.8 oz. per acre. Do not exceed 8.4 oz. per acre per year. Allow 7 days between applications REI: 12-hour. PHI: 3-day

**bifenthrin formulations (bifenthrin)** *Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* There are many bifenthrin pesticides, including Bifenture®, Brigade®, Capture®, Discipline®, Fanfare®, Tundra®, and Sniper®. For 2EC formulations: Apply 5.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. Allow 7 days between applications. For WSB formulations:

Apply 12.8-16.0 oz. per acre. Do not exceed 80 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 1-day for beet; 21-day carrot, celeriac, parsnip, radish, rutabaga, and turnip. *RUP*.

**Malathion 5EC® (malathion)** *Beet, Parsnip, Radish, Rutabaga, Turnip* 1-2 pts. per acre for turnip. 1.5-2.0 pts. per acre for beet and parsnip. 1.6 pts. per acre for rutabaga. Do not exceed 3 applications per season. REI: see label. PHI: 7-day.

**Platinum 75SG® (thiamethoxam)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 5.0-12.0 fl. oz. per acre for beet, carrot, parsnip, rutabaga, and turnip. 5.0-6.5 fl. oz. per acre for radish. Apply as in-furrow spray at planting, as an overhead application immediately after planting with sufficient irrigation to incorporate, or through drip irrigation. Do not exceed 12.0 fl. oz. per acre per season. REI: 12-hour.

**Sivanto 200SL® (flupyradifurone)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 7.0-10.5 fl. oz. per acre. Do not exceed 28.0 fl. oz. per acre per season. Allow 10 days between applications. REI: 4-hour. PHI: 7-day.

### Armyworm Caterpillars

**bifenthrin formulations (bifenthrin)** *Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* There are many bifenthrin pesticides, including Bifenture®, Brigade®, Capture®, Discipline®, Fanfare®, Tundra®, and Sniper®. For 2EC formulations: Apply 5.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. Allow 7 days between applications. For WSB formulations: Apply 12.8-16.0 oz. per acre. Do not exceed 80 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 1-day for beet; 21-day carrot, celeriac, parsnip, radish, rutabaga, and turnip. *RUP*.

**Coragen® (chlorantraniliprole)** *Rutabaga* 3.5-7.5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per crop, or 16.4 fl. oz. per acre per year. Allow 3 days between applications. REI: 4-hour. PHI: 1-day.

**Radiant 1SC® (spinetoram)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 6-8 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season for radish, rutabaga, and turnip. Do not exceed 28 fl. oz. per acre per season for carrot and parsnip. Do not exceed 32 fl. oz. per acre per season for beet. Allow 7 days between applications. REI: 4-hour. PHI: 3-day for carrot, parsnip, radish, rutabaga, and turnip; 7-day for beet.

**Sevin XLR Plus® (carbaryl)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 1-2 qts. per acre. Do not exceed 6 qts. per acre. REI: 12-hour. PHI: 7-day.

### Cabbageworm Caterpillars

**bifenthrin formulations (bifenthrin)** *Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* There are many bifenthrin pesticides, including Bifenture®, Brigade®, Capture®, Discipline®, Fanfare®, Tundra®, and Sniper®. For 2EC formulations: Apply 5.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. Allow 7 days between applications. For WSB formulations: Apply 12.8-16.0 oz. per acre. Do not exceed 80 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 1-day for beet; 21-day carrot, celeriac, parsnip, radish, rutabaga, and turnip. *RUP*.

### Cutworm Caterpillars

Treatment is warranted when 25% of plants are infested.

**Asana XL® (esfenvalerate)** *Carrot* 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** *Carrot, Radish* 1.6-2.8 fl. oz. per acre. Do not exceed 14.0 fl. oz. per acre per season. Do not harvest tops for human consumption. REI: 12-hour. PHI: 0-day *RUP*.

**bifenthrin formulations (bifenthrin)** *Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* There are many bifenthrin pesticides, including Bifenture®, Brigade®, Capture®, Discipline®, Fanfare®, Tundra®, and Sniper®. For 2EC formulations: Apply 5.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. Allow 7 days between applications. For WSB formulations: Apply 12.8-16.0 oz. per acre. Do not exceed 80 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 1-day for beet; 21-day carrot, celeriac, parsnip, radish, rutabaga, and turnip. *RUP*.

**diazinon formulations (diazinon)** *Beet, Carrot, Radish* Broadcast and incorporate preplant. For 50W formulations: 4-8 lbs. per acre. Do not exceed one application per year. For 500W formulations: 2-4 qts. per acre. Do not exceed 4 qts. per acre per season. For 600W formulations: 51-102 fl. oz. per acre. Do not exceed 102 fl. oz. per acre per season. PHI: NA *RUP*.

**Lannate LV® (methomyl)** *Beet, Carrot* 0.75-1.5 pts. per acre for carrot. 1.5 pts. per acre for beet. Do not exceed 21 pts. per acre per season for carrot. Do not exceed 12 pts. per acre per season for beet. REI: 48-hour. PHI: 0-day for beet roots, 10-day for beet tops, 1-day for carrot. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 1.28-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per

*OMRI-listed indicates that the product is listed by the Organic Materials Review Institute (OMRI.org) and therefore may be acceptable for use in organic production. Check with your certifier before use.*

season. Allow 4 days between applications. Leaves cannot be used for food or feed. REI: 12-hour. PHI: 1-day. *RUP*.

**Sevin XLR Plus® (carbaryl)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 1-2 qts. per acre. Do not exceed 6 qts. per acre. REI: 12-hour. PHI: 7-day.

### **Flea Beetles**

**Actara® (thiamethoxam)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 1.5-3.0 oz. per acre. Do not exceed 4.0 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 7-day.

**Asana XL® (esfenvalerate)** *Radish, Turnip* 5.8-9.6 fl. oz. per acre. Do not exceed 77 fl. oz. per acre per season for turnip. Do not exceed 19.4 fl. oz. per acre per season for radish. REI: 12-hour. PHI: 7-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** *Carrot, Radish* 1.6-2.8 fl. oz. per acre. Do not exceed 14.0 fl. oz. per acre per season. Do not harvest tops for human consumption. REI: 12-hour. PHI: 0-day *RUP*.

**bifenthrin formulations (bifenthrin)** *Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* There are many bifenthrin pesticides, including Bifenture®, Brigade®, Capture®, Discipline®, Fanfare®, Tundra®, and Sniper®. For 2EC formulations: Apply 5.1-6.4 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. Allow 7 days between applications. For WSB formulations: Apply 12.8-16.0 oz. per acre. Do not exceed 80 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 1-day for beet; 21-day carrot, celeriac, parsnip, radish, rutabaga, and turnip. *RUP*.

**Platinum 75SG® (thiamethoxam)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 5.0-12.0 fl. oz. per acre for beet, carrot, parsnip, rutabaga, and turnip. 5.0-6.5 fl. oz. per acre for radish. Apply as in-furrow spray at planting, as an overhead application immediately after planting with sufficient irrigation to incorporate, or through drip irrigation. Do not exceed 12.0 fl. oz. per acre per season. REI: 12-hour.

**Sevin XLR Plus® (carbaryl)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 0.5-1 qts. per acre. Do not exceed 6 qts. per acre. REI: 12-hour. PHI: 7-day.

### **Leafhoppers**

*Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* Use an insecticide to control leafhoppers that transmit the disease. Controlling leafhoppers early in the season is essential. Leafhoppers must be controlled before they feed.

**Actara® (thiamethoxam)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 1.5-3.0 oz. per acre. Do not exceed 4.0 oz. per acre per season. Allow 7 days between applications. REI: 12-hour. PHI: 7-day.

**Admire Pro® (imidacloprid)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 0.31-0.74 fl. oz. per 1,000 ft. of row. Apply as chemigation through drip, as an in-furrow spray, shanked in to seed trench, or as a narrow banded spray over eventual row within 14 days of planting. REI: 12-hour. PHI: 21-day.

**Asana XL® (esfenvalerate)** *Carrot* 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** *Carrot, Radish* 1.6-2.8 fl. oz. per acre. Do not exceed 14.0 fl. oz. per acre per season. Do not harvest tops for human consumption. REI: 12-hour. PHI: 0-day *RUP*.

**Lannate LV® (methomyl)** *Carrot* 1.5-3.0 pts. per acre. Do not exceed 21 pts. per acre per crop. REI: 48-hour. PHI: 1-day. *RUP*.

**Platinum 75SG® (thiamethoxam)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 5.0-12.0 fl. oz. per acre for beet, carrot, parsnip, rutabaga, and turnip. 5.0-6.5 fl. oz. per acre for radish. Apply as in-furrow spray at planting, as an overhead application immediately after planting with sufficient irrigation to incorporate, or through drip irrigation. Do not exceed 12.0 fl. oz. per acre per season. REI: 12-hour.

**Sevin XLR Plus® (carbaryl)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 0.5-1 qts. per acre. Do not exceed 6 qts. per acre. REI: 12-hour. PHI: 7-day.

**Sivanto 200SL® (flupyradifurone)** *Beet, Carrot, Celeriac, Parsnip, Radish, Rutabaga, Turnip* 7.0-10.5 fl. oz. per acre. Do not exceed 28.0 fl. oz. per acre per season. Allow 10 days between applications. REI: 4-hour. PHI: 7-day.

### **Seed and Root Maggots**

**diazinon formulations (diazinon)** *Rutabaga* See below.

Broadcast and incorporate preplant. For 50W formulations: 4-6 lbs. per acre. Do not exceed one application per year. For 500W formulations: 2-4 qts. per acre. Do not exceed 4 qts. per acre per season. For 600W formulations: 51-102 fl. oz. per acre. Do not exceed 102 fl. oz. per acre per season. PHI: NA. *RUP*.

**Lorsban 15G® (chlorpyrifos)** *Radish, Rutabaga, Turnip* 4.6-9.2 oz. per 1,000 ft. of row. Apply as an in-furrow drench at planting. Do not exceed 15 lbs. per acre per crop. REI: see label.

# Sweet Corn

## Sweet Corn Types

Sweet corn is usually described by color (yellow, bicolor, or white) and by the major genes that make it sweet. The original sweet corn (called standard, sugary, or su) contains the su1 genetic variant that makes it sweet instead of starchy like field corn. Sugary sweet corn is grown today primarily for processing and specialized markets.

A second type of sweet corn is called sugar-enhanced, sugary enhancer, EH, or se corn because it contains the se1 genetic variant that increases sugar content and makes the kernels more tender. Heterozygous se corn has one copy of the se1 mutation, and homozygous se corn has two copies of the se1 mutation, increasing its effect. Sugar-enhanced sweet corn is grown primarily for direct retail sales and local wholesale markets.

A third type of sweet corn, called supersweet, ultrasweet, extra sweet, or shrunken-2 contains the sh2 genetic variation. This type typically has a higher sugar content than sugary corn, and the sugar content does not decline rapidly after picking, so it remains sweet for several days after harvest. Kernels typically are not as tender as se corn. Supersweet types are grown for retail sales, local fresh markets, and wholesale shipping markets.

Some of the newest sweet corn varieties combine the sh2 with su and/or se genetics in new ways. Many of these new varieties have performed well in Midwestern trials and are gaining popularity. The new types are often identified by trademarked brand names and described as having enhanced eating quality. Consult with seed company representatives and sweet corn trial researchers to identify varieties suitable for your needs.

## Isolation Requirements

Sweet corn flavor is affected by pollen source. All sweet corn types should be isolated from field corn pollen by 250 feet or by a 14-day difference in tasselling dates. Supersweet (sh2) varieties must be similarly isolated from sugary and sugar-enhanced types. If not isolated, kernels of both varieties will be starchy instead of sweet.

It is not essential to isolate sugar-enhanced (se) sweet corn from sugary (su) sweet corn: cross-pollination will not result in starchy kernels. However, isolation permits the full expression of sugar-enhanced traits. Likewise, to get the full benefits of new genetics, isolation is usually recommended for the new combinations of sh2 and se

or su. If complete isolation is not possible, plants should at least be isolated from pollen that will increase the proportion of starchy kernels. Refer to the table below for isolation requirements or check with your seed supplier.

To maintain color purity, isolate white corn from yellow or bi-color corn. Pollen from yellow or bi-color corn will cause some yellow kernels in white varieties. Pollen from yellow corn will lead to extra yellow kernels in bi-color varieties. Pollen from white corn will not affect yellow or bi-color varieties.

### Sweet Corn Isolation Requirements<sup>1</sup>

Corn Type or Brand	Isolate from these Types or Brands
Standard (su)	Shrunken-2, Xtra Tender, Gourmet Sweet
Sugar-enhanced (se)	Shrunken-2, Xtra Tender, Gourmet Sweet
TripleSweet, Synergistic	Shrunken-2, Xtra Tender, Gourmet Sweet
Shrunken-2 (sh2)	Standard, Sugar-enhanced, TripleSweet, Synergistic
Xtra Tender, Gourmet Sweet	Standard, Sugar-enhanced, TripleSweet, Synergistic

<sup>1</sup>Isolate all types from field corn.

## Spacing

Rows 30 to 40 inches apart. Plant early varieties 8 to 10 inches apart in the row, late varieties 9 to 12 inches apart in the row.

Seed 10 to 15 pounds per acre.

## Fertilizing

**Lime:** To maintain a soil pH of 6.0 to 6.5.

**Preplant:** N: 60 pounds per acre. P<sub>2</sub>O<sub>5</sub>: 0 to 100 pounds per acre. K<sub>2</sub>O: 0 to 150 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. For early season varieties, apply a starter fertilizer at planting. Do not exceed 80 to 100 pounds of N + K<sub>2</sub>O per acre in the fertilizer band (2 inches to the side of the row and 2 inches below the seed). A good starter fertilizer would be 200 pounds per acre of 6-24-24, or 10 gallons of 10-34-0 or similar analysis. On sandy soils, broadcast 30 pounds or band 15 pounds of sulfur per acre.

**Sidedress N:** For loam or finer textured soils, apply 30 to 40 pounds N per acre when plants are 4 to 5 inches tall, and before they are 10 inches tall. If the soil organic matter content exceeds 3 percent and/or sweet corn follows a legume, this sidedressed N application could be skipped unless there has been excessive rainfall. For irrigated sandy loam soils along river areas, the N preplant application should be replaced with two sidedressings of approximately 40 pounds N per acre each: one when 4 to 5 inches tall (4th to 5th leaf), and the other at 10 inches tall (10th to 12th leaf).

## Pesticide Use in Greenhouses

Before using any pesticide, always read the product label for mention of greenhouse restrictions. See Selected Information About Recommended Fungicides (page 79), Selected Information About Recommended Herbicides (page 69), and Selected Information About Recommended Insecticides (page 54).

## Disease Control

### Recommended Controls

#### ***Anthracnose of Corn - Colletotrichum Fungus***

**Crop rotation** Rotate between crop families to reduce disease inoculum buildup.

**Aproach® (picoxystrobin)** 3-12 fl. oz. per acre. Use 3-6 fl. oz. rate for single application for early disease control between V4 and V7. Use the 6-12 fl. oz. rate for repeated applications for continued season long control between VT and R3. See label. REI: 12-hour. PHI: 7-day.

**azoxystrobin formulations (azoxystrobin)** Most formulations are 6-15.5 fl. oz. per acre for anthracnose and 6-9 fl. oz. per acre for rust. REI: 4-hour. PHI: 7-day.

**Elatus® (azoxystrobin, benzovindiflupyr (solatenol))** 5-7.3 oz. per acre. REI: 12-hour. PHI: 7-day.

**Headline® (pyraclostrobin)** 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Headline AMP® (pyraclostrobin, metconazole)** 10-14.4 fl. oz. per acre. REI: 12-hour. PHI: 20-day.

**Priaxor® (fluxapyroxad, pyraclostrobin)** 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Quilt® (azoxystrobin, propiconazole)** 10.5-14 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Quilt Xcel® (azoxystrobin, propiconazole)** 10.5-14 fl. oz. per acre. Use lower rate for early season applications. See label. REI: 12-hour. PHI: 14-day.

**Stratego® (propiconazole, trifloxyystrobin)** 10 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

#### ***Northern Corn Leaf Blight of Corn - *Exserohilum* or *Helminthosporium* Fungus***

**Crop rotation** Rotate between crop families to reduce disease inoculum buildup.

**Aproach® (picoxystrobin)** 3-12 fl. oz. per acre. Use 3-6 fl. oz. rate for single application for early disease control between V4 and V7. Use the 6-12 fl. oz. rate for repeated applications for continued season long control between VT and R3. See label. REI: 12-hour. PHI: 7-day.

**azoxystrobin formulations (azoxystrobin)** Most formulations are 6-15.5 fl. oz. per acre for anthracnose and 6-9 fl. oz. per acre for rust. REI: 4-hour. PHI: 7-day.

**chlorothalonil formulations (chlorothalonil)** REI: 12-hour.

**Elatus® (azoxystrobin, benzovindiflupyr (solatenol))** 5-7.3 oz. per acre. REI: 12-hour. PHI: 7-day.

**Headline® (pyraclostrobin)** 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Headline AMP® (pyraclostrobin, metconazole)** 10-14.4 fl. oz. per acre. REI: 12-hour. PHI: 20-day.

**mancozeb formulations (mancozeb)** REI: 24-hour. PHI: 7-day.

**Priaxor® (fluxapyroxad, pyraclostrobin)** 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**propiconazole formulations (propiconazole)** Labeled formulations include Propimax EC®, Propiconazole 3.6 EC®, Propiconazole 41.8% EC®, Tilt®. REI: 12-hour. PHI: 14-day.

**Quilt® (azoxystrobin, propiconazole)** 7-14 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Quilt Xcel® (azoxystrobin, propiconazole)** 10.5-14 fl. oz. per acre. Use lower rate for early season applications. See label. REI: 12-hour. PHI: 14-day.

**Stratego® (propiconazole, trifloxyystrobin)** 10 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**tebuconazole formulations (tebuconazole)** Labeled formations include Monsoon®, Orius 3.6F®, Onset 3.6L®, Tebuconazole 3.6F®, Toledo 3.6F®, Vibe®. REI: see label. PHI: 7-day.

## ***Northern Corn Leaf Spot of Corn - Bipolaris Fungus***

**Crop rotation** Rotate between crop families to reduce disease inoculum buildup.

**Aproach (picoxystrobin)** 3-12 fl. oz. per acre. Use 3-6 fl. oz. rate for single application for early disease control between V4 and V7. Use the 6-12 fl. oz. rate for repeated applications for continued season long control between VT and R3. See label. REI: 12-hour. PHI: 7-day.

**azoxystrobin formulations (azoxystrobin)** Most formulations are 6-15.5 fl. oz. per acre for anthracnose and 6-9 fl. oz. per acre for rust. REI: 4-hour. PHI: 7-day.

**chlorothalonil formulations (chlorothalonil)** REI: 12-hour.

**Elatus® (azoxystrobin, benzovindiflupyr (solanol))** 5-7.3 oz. per acre. REI: 12-hour. PHI: 7-day.

**Headline® (pyraclostrobin)** 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Headline AMP® (pyraclostrobin, metconazole)** 10-14.4 fl. oz. per acre. REI: 12-hour. PHI: 20-day.

**mancozeb formulations (mancozeb)** REI: 24-hour. PHI: 7-day.

**Priaxor® (fluxapyroxad, pyraclostrobin)** 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**propiconazole formulations (propiconazole)** Labeled formulations include Propimax EC®, Propiconazole 3.6 EC®, Propiconazole 41.8% EC®, Tilt. REI: 12-hour. PHI: 14-day.

**Quilt® (azoxystrobin, propiconazole)** 7-14 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Quilt Xcel® (azoxystrobin, propiconazole)** 10.5-14 fl. oz. per acre. Use lower rate for early season applications. See label. REI: 12-hour. PHI: 14-day.

**Stratego® (propiconazole, trifloxystrobin)** 10 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**tebuconazole formulations (tebuconazole)** Labeled formations include Monsoon®, Orius 3.6F®, Onset 3.6L®, Tebuconazole 3.6F®, Toledo 3.6F®, Vibe®. REI: see label. PHI: 7-day.

## ***Rust of Multiple Crops - Puccinia Fungus***

**Variety selection** Plant resistant hybrids. Sweet corn hybrid resistance to rust will depend on the hybrid's particular Rp-resistant gene, its general (background) resistance, and the race(s) of the rust prevalent in the planting.

**Aproach® (picoxystrobin)** 3-12 fl. oz. per acre. Use 3-6 fl. oz. rate for single application for early disease control between V4 and V7. Use the 6-12 fl. oz. rate for repeated applications for continued season long control between VT and R3. See label. REI: 12-hour. PHI: 7-day.

**azoxystrobin formulations (azoxystrobin)** Most formulations are 6-15.5 fl. oz. per acre for anthracnose and 6-9 fl. oz. per acre for rust. REI: 4-hour. PHI: 7-day.

**chlorothalonil formulations (chlorothalonil)** REI: 12-hour.

**Elatus® (azoxystrobin, benzovindiflupyr (solanol))** 5-7.3 oz. per acre. REI: 12-hour. PHI: 7-day.

**Headline® (pyraclostrobin)** 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Headline AMP® (pyraclostrobin, metconazole)** 10-14.4 fl. oz. per acre. REI: 12-hour. PHI: 20-day.

**mancozeb formulations (mancozeb)** REI: 24-hour. PHI: 7-day.

**Priaxor® (fluxapyroxad, pyraclostrobin)** 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**propiconazole formulations (propiconazole)** Labeled formulations include Propimax EC®, Propiconazole 3.6 EC®, Propiconazole 41.8% EC®, Tilt. REI: 12-hour. PHI: 14-day.

**Quilt® (azoxystrobin, propiconazole)** 10.5-14 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Quilt Xcel® (azoxystrobin, propiconazole)** 10.5-14 fl. oz. per acre. Use lower rate for early season applications. See label. REI: 12-hour. PHI: 14-day.

**Stratego® (propiconazole, trifloxystrobin)** 10 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**tebuconazole formulations (tebuconazole)** Labeled formations include Monsoon, Orius 3.6F®, Onset 3.6L®, Tebuconazole 3.6F®, Toledo 3.6F®, Vibe®. REI: see label. PHI: 7-day.

## ***Smut of Corn - Ustilago Fungus***

Some hybrids tend to have fewer infections. Use past experience to choose successful hybrids. Avoid mechanical damage to corn plant. Avoid plant stresses that affect pollen production and silk emergence.

**Variety selection** Plant resistant hybrids.

**Southern Corn Leaf Blight of Corn - Bipolaris Fungus**

**Crop rotation** Rotate between crop families to reduce disease inoculum buildup.

**Aproach® (azoxystrobin)** 3-12 fl. oz. per acre. Use 3-6 fl. oz. rate for single application for early disease control between V4 and V7. Use the 6-12 fl. oz. rate for repeated applications for continued season long control between VT and R3. See label. REI: 12-hour. PHI: 7-day.

**azoxystrobin formulations (azoxystrobin)** Most formulations are 6-15.5 fl. oz. per acre for anthracnose and 6-9 fl. oz. per acre for rust. REI: 4-hour. PHI: 7-day.

**chlorothalonil formulations (chlorothalonil)** REI: 12-hour.

**Elatus® (azoxystrobin, benzovindiflupyr (solatenol))** 5-7.3 oz. per acre. REI: 12-hour. PHI: 7-day.

**Headline® (pyraclostrobin)** 6-12 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**Headline AMP® (pyraclostrobin, metconazole)** 10-14.4 fl. oz. per acre. REI: 12-hour. PHI: 20-day.

**mancozeb formulations (mancozeb)** REI: 24-hour. PHI: 7-day.

**Priaxor® (fluxapyroxad, pyraclostrobin)** 4-8 fl. oz. per acre. REI: 12-hour. PHI: 7-day.

**propiconazole formulations (propiconazole)** Labeled formulations include Propimax EC, Propiconazole 3.6 EC, Propiconazole 41.8%EC, Tilt. REI: 12-hour. PHI: 14-day.

**Quilt® (azoxystrobin, propiconazole)** 7-14 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Quilt Xcel® (azoxystrobin, propiconazole)** 10.5-14 fl. oz. per acre. Use lower rate for early season applications. See label. REI: 12-hour. PHI: 14-day.

**Stratego® (propiconazole, trifloxystrobin)** 10 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**tebuconazole formulations (tebuconazole)** Labeled formations include Monsoon®, Orius 3.6F®, Onset 3.6L®, Tebuconazole 3.6F®, Toledo 3.6F®, Vibe®. REI: see label. PHI: 7-day.

**Stewart's Wilt of Corn - Pantoea Bacteria**

Use an insecticide or seed treatment to control the flea beetles that transmit Stewart's wilt. Insecticide treatments are more likely to be necessary in season following a mild winter and when using susceptible varieties.

**Variety selection** Plant wilt-resistant, or partially resistant hybrids.

**Viruses of Multiple Crops - Multiple Pathogens**

**Variety selection** Virus diseases include maize dwarf mosaic, chlorotic dwarf, wheat streak mosaic. Plant resistant or partially resistant varieties. Control Johnson grass and volunteer wheat.

**Weed Control****Recommended Controls****Burndown or Directed/Shielded**

**glyphosate formulations (glyphosate)** 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations of 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qts. per acre, or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qts. per acre. Broadcast before or after planting but before crop emerges, or apply up to 0.75 lb. acid equivalent between crop rows with wipers, hooded or shielded sprayers after corn is 12 inches tall. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. REI: 4-hour. PHI: 7-day.

**paraquat formulations (paraquat)** 2-4 pt. per acre of 2 lb. per gal. formulation or 1.3-2.7 pt. per acre of 3 lb. per gal. formulation. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS (0.25% v/v) per 25 gals. of solution. Apply before or after seeding but before crop emerges. Or apply after crop emergence and use a hooded or shielded sprayers to prevent spray from contacting crop. Or wait until corn is more than 10 inches tall and apply between rows using directed spray that reaches no higher than 3 inches up the corn stalk. Corn plants contacted by spray may be injured or killed. Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 24-hour. RUP.

**Preemergence Broadleaf and Grass Weeds****acetochlor formulations (acetochlor)**

**Harness® (acetochlor)** 1.5-3.0 pts. per acre.

**Surpass EC® (acetochlor)** 1.5-3.75 pts. per acre.

**TopNotch® (acetochlor)** 2-3 qts. per acre.

Do not apply postemergence. Use lower rates on coarse soils with low organic matter. Apply before planting and incorporate, or apply after planting

before sweet corn emerges. May be mixed with atrazine or simazine. See label for details. Do not apply to light textured soils specified in the label where ground water is at 30 ft. or less. REI: 12-hour.

**acetochlor plus atrazine formulations (acetochlor, atrazine)**

**Breakfree ATZ® (acetochlor, atrazine)** 2.2-3.4 qts. per acre.

**Breakfree ATZ Lite® (acetochlor, atrazine)** 1.6-3 qts. per acre.

**Degree Xtra® (acetochlor, atrazine)** 2.9-3.7 qts. per acre.

**FulTime® (acetochlor, atrazine)** 2.5-5 qts. per acre.

**Harness Xtra® (acetochlor, atrazine)** 1.8-3.3 qts. per acre.

**Harness Xtra 5.6L® (acetochlor, atrazine)** 1.4-3 qts. per acre.

**Keystone® (acetochlor, atrazine)** 2.2-3.4 qts. per acre.

**Keystone LA® (acetochlor, atrazine)** 1.6-3 qts. per acre.

Do not apply postemergence. Use lower rates on coarse soils with low organic matter. Apply before planting and incorporate, or apply after planting before sweet corn emerges. See label for details. Do not apply to light textured soils specified in the label where ground water is at 30 ft. or less. REI: 12-hour. PHI: 45-day for forage uses. *RUP*.

**Acuron® (atrazine, mesotrione, s-metolachlor, bicyclopyrone)** 2.5 qts. per acre on soil with less than 3% organic matter; 3 qts. per acre on soil with more than 3% organic matter. For control of most broadleaf and grass weeds. Control may be reduced on soils with >10% organic matter. Do not apply after sweet corn has emerged or severe crop injury may occur. 18-month replant restriction for all crops except corn types (no restrictions); small grains (4 months); dry beans, potato, and soybean (10 months). Contains atrazine so state restrictions for atrazine apply. REI: 24-hour. PHI: 45-day for grazing or forage feeding, 60-day for forage harvest. *RUP*.

**Anthem ATZ® (atrazine, pyroxasulfone, fluthiacet-methyl)** 1.5-4 pts. per acre. Adjust rate based on % organic matter in soil and soil texture, and pre or postemergence use, see label. Preplant surface applications are not recommended for sweet corn. For processing sweet corn only when used

postemergence. Apply post from crop emergence through V4 growth stage. Add an adjuvant such as a NIS or a silicone-based surfactant at 8 fl. oz. per 25 gals. of spray solution, or add COC or MSO at 1-2 pts. per acre for best activity. In addition to an adjuvant, you can add UAN at 1-2 qts. per acre or spray grade AMS at recommended-use rates to the spray solution. Before applying to corn, confirm that your line has Anthem selectivity with your seed company or supplier to avoid injury to sensitive lines. Avoid postemergence application when crop foliage is wet or prior to or after a rain because a crop response can occur. However, the crop will recover. Do not apply if crop is under stress and do not irrigate within 4 hours of a postemergence application. Do not make more than 1 application to spring corn. See label for crop rotation intervals. REI: 12-hour. PHI: 45-day. *RUP*.

**Anthem Maxx® (pyroxasulfone, fluthiacet-methyl)**

2.5-6.5 fl. oz. per acre. Adjust rate based on % organic matter in soil and soil texture, and pre or postemergence use, see label. Preplant surface applications are not recommended for sweet corn. For processing sweet corn only when used postemergence. Apply post from crop emergence through V4 growth stage. Add an adjuvant such as a NIS or a silicone-based surfactant at 8 fl. oz. per 25 gals. of spray solution, or add COC or MSO at 1-2 pts. per acre for best activity. In addition to an adjuvant, you can add UAN at 1-2 qts. per acre or spray grade AMS at recommended-use rates to the spray solution. Before applying to corn, confirm that your line has Anthem selectivity with your seed company or supplier to avoid injury to sensitive lines. Avoid postemergence application when crop foliage is wet or prior to or after a rain because a crop response can occur. However, the crop will recover. Do not apply if crop is under stress and do not irrigate within 4 hours of a postemergence application. REI: 12-hour. PHI: 40-day.

**atrazine (atrazine)** Use 4L formulations at 1-2 qts. per acre. Use 90W formulations at 1.1-2.2 lbs. per acre. To control small, emerged broadleaves, include 1 qt. of COC per acre. Apply before planting and incorporate, after planting before corn emerges, or after emergence before corn is 12 inches tall. Potential for carryover in soil and injury to following crops. Consult label for details. Do not exceed 1.6 qts. of 4L or 1.77 lbs. of 90W per acre before corn emerges on highly erodible soils with low residue; do not exceed 2.5 qts. or 2.77 lbs. total per acre per year. REI: 12-hour. *RUP*.

**dimethenamid-p plus atrazine formulations  
(dimethenamid-p, atrazine)**

**Commit ATZ® (atrazine, dimethenamid-p)** 2.5-4.6 pts. per acre.

**Commit ATZ Lite® (dimethenamid-p, atrazine)** 2.0 to 3.5 pts. per acre.

**Guardsman Max® (dimethenamid-p, atrazine)** 2.5-4.6 pts. per acre.

Use low rates on coarse soils with low organic matter. Apply before planting and incorporate, or after planting before corn emerges, or after emergence before corn is 12 inches tall. Rates may be reduced if corn will be cultivated or full-season control is not needed. If multiple applications are made, do not exceed maximum rate per acre per year. REI: 12-hour. PHI: 50-day. *RUP*.

**Dual Magnum® or Dual II Magnum® (s-metolachlor)**

1-2 pts. per acre. Use lower rate on coarse soils. Apply before planting and incorporate, or apply after planting but before corn emerges. May also be applied as a directed spray between rows when corn is 5-40 inches tall. Incorporate to control nutsedge. May be mixed with atrazine, see label for details. Do not exceed 3.9 pts. per acre per year. REI: 24-hour. PHI: 30-day.

**Lexar® or Lexar EZ® (atrazine, s-metolachlor, mesotrione)** 3 or 3.5 qts. per acre. Use low rate on soils with organic matter less than 3%. Apply up to 14 days before planting or apply after planting before corn emerges. To control emerged broadleaves include COC at 1% v/v or NIS at 0.25% v/v. Note organophosphate insecticide precautions. Do not use these products if topramezone (such as Impact®) or other products containing mesotrione (such as Callisto®) have been or will be applied the same growing season. Do not exceed 3.5 qts. of Lexar® per acre per year. PHI: 60-day. *RUP*.

**Lumax® or Lumax EZ® (s-metolachlor, atrazine, mesotrione)** Use Lumax® at 2.5 or 3 qts. per acre. Use Lumax EZ® at 2.5 or 3 qts. per acre. Use low rate on soils with organic matter less than 3%. Apply up to 14 days before planting or apply after planting before corn emerges. To control emerged broadleaves include COC at 1% v/v or NIS at 0.25% v/v. Note organophosphate insecticide precautions. Do not use this products if topramezone (such as Impact®) or other products containing mesotrione (such as Callisto®) have been or will be applied the same growing season. Do not exceed 3 qts. of Lumax® or

3.25 qts. of LumaxEZ® per acre per year. REI: 24-hour. PHI: 60-day. *RUP*.

**Outlook® (dimethenamid-p)** 10-21 fl. oz. per acre. Use lower rate on coarse soils low in organic matter. Apply before planting and incorporate, or after planting before corn emerges, or after emergence before corn is 12 inches tall. Apply preemergence for best activity. Do not exceed 21 fl. oz. of Outlook per acre per year. REI: 12-hour. PHI: 50-day.

**pendimethalin formulations (pendimethalin)** Use

Prowl H2O® and Satellite Hydrocap® at 2-4 pts. per acre or Prowl 3.3EC at 1.8-4.8 pts. per acre. Use low rates on coarse soils with low organic matter. Apply after planting but before corn emerges, or after emergence until corn is 20-24 in. tall or shows 8 leaf collars. Plant corn at least 1.5 inches deep and make sure seed is well covered. Use drop nozzles and directed spray for post applications, if necessary, to get spray to soil. Do not apply both before and after corn emergence. REI: 24-hour.

**s-metolachlor formulations (s-metolachlor)** products containing 7.6 lbs. a.i. per gal. at 1-2 pts. per acre. Use lower rate on coarse soils. Apply before planting and incorporate, or apply after planting before corn emerges. May also be applied as a directed spray between rows when corn is 5-40 inches tall. Incorporate to control nutsedge. May be mixed with atrazine, see label for details. Do not exceed 3.9 pts. per acre per year. REI: 24-hour.

**s-metolachlor plus atrazine formulations (atrazine, s-metolachlor)**

**Bicep II Magnum®** 1.3-2.6 qts. per acre.

**Bicep II Magnum FC®** 1.3-2.6 qts. per acre.

**Bicep Lite II Magnum®** 0.9-2.2 qts. per acre.

**Charger Max ATZ®** 1.3-2.6 qts. per acre.

**Charger Max ATZ Lite®** 0.9-2.2 qts. per acre.

**Cinch ATZ®** 1.3-2.6 qts. per acre.

**Cinch ATZ Lite®** 0.9-2.2 qts. per acre.

Use low rates on coarse soils with low organic matter. Apply before planting and incorporate, or after planting before corn emerges, or after emergence before corn is 5 inches tall. May also be applied as a directed spray between rows when corn is 5-12 inches tall. Do not exceed 3.2 qts. per acre per year of products with 3.1 lbs. atrazine per gallon. Do not exceed 3.75 qts. per acre per year of products with 2.67 lbs. atrazine per gallon. REI: 24-hour. PHI: 30-day. *RUP*.

**Zidua® (pyroxasulfone)** 1.0-4.0 oz. per acre. Apply before or after planting and before crop emergence, or at spiking up to V4 (4 leaf collars visible). May be incorporated. Will not control emerged weeds. May be tank-mixed or applied sequentially with many other products. Seed at least 1 inch deep. Do not exceed 2.75 oz. per acre per season on coarse soils. Do not exceed 5 oz. per acre per season on other soils. REI: 12-hour. PHI: 37-day.

### **Preemergence Broadleaf Weeds**

**Callisto® (mesotrione)** 6-7.7 fl. oz. per acre preemergence, 3 fl. oz. per acre postemergence. Processing and fresh market varieties. Some varieties may be severely injured. If weeds are present, add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Do not add UAN or AMS when applying to emerged sweet corn. Adding atrazine at 0.25-0.5 lb. of a.i. per acre for post applications, or 0.75 lb. a.i. per acre for pre applications will improve weed control. Note organophosphate insecticide precautions. Do not exceed 0.24 lb. mesotrione per acre per year (7.7 fl. oz. Callisto®) from all sources. REI: 12-hour. PHI: 45-day.

**halosulfuron formulations (halosulfuron)** 2/3-1 oz. per acre for products with 75% active ingredient. Apply over the top or with drop nozzles from the spike through layby stages. Has some soil residual activity. A second application of 2/3 oz. per acre may be made only with drop nozzles aimed to avoid application into whorls. Do not exceed 2 applications per 12-month period. Products include Sandea®, Permit®, Profine®. REI: 12-hour. PHI: 30-day.

### **Postemergence Broadleaf and Grass Weeds**

**atrazine formulations (atrazine)** See recommendations in the Preemergence Broadleaf and Grass Weeds section of this chapter.

**Accent Q® (nicosulfuron)** 0.45-0.90 oz. per acre. Use 1 qt. of COC or 8 fl. oz. of NIS per 25 gals. of spray solution. Apply broadcast or with drop nozzles on corn up to 12 inches tall or up through 5 leaf collars. For corn 12-18 inches tall use drop nozzles. Do not apply to corn more than 18 inches tall or showing 6 leaf collars or more. Cultivars differ in sensitivity to this herbicide; get information on cultivars prior to use. Not recommended for use on corn previously treated with Counter®, Lorsban®, or Thimet® insecticides. REI: 4-hour.

**Impact® (topramezone)** 0.5-0.75 fl. oz. per acre. Add MSO or COC and urea ammonium nitrate (UAN), ammonium phosphate (10-34-0), or ammonium sulfate. See label for additive rates. Tank-mixing with atrazine will improve efficacy and spectrum of weed species controlled. Not recommended if products containing mesotrione have been or will be applied to crop. REI: 12-hour. PHI: 45-day.

**Laudis® (tembotrione)** 3 oz. per acre. Apply with 1% v/v MSO plus 8.5 lb. of AMS per 100 gal. of spray solution. COC is less efficacious than MSO but can be used instead of MSO when broadleaves are the main target and conditions for control are excellent. Tank-mixing with atrazine will improve efficacy and spectrum of weed species controlled. REI: 12-hour.

**Lexar® or Lexar EZ® (atrazine, s-metolachlor, mesotrione)** See recommendations in the Preemergence Broadleaf and Grass Weeds section of this chapter.

**Lumax® or Lumax EZ® (s-metolachlor, atrazine, mesotrione)** See recommendations in the Preemergence Broadleaf and Grass Weeds section of this chapter.

**Revulin Q® (nicosulfuron, mesotrione)** 3.4 to 4.0 oz. per acre. Use with NIS after emergence until 12 inches tall or 5 leaf-collar stage. Use drop nozzles for corn between 12 and 18 inches tall. Do not apply to sweet corn taller than 18 inches or at 6 leaf-collar stage or later. Do not use AMS or UAN adjuvants. Because of the adjuvant restrictions, better results will be obtained when applied to smaller weeds. Can use COC under dry conditions to improve weed control, but may increase crop injury. 18-month replant restriction for all crops except field corn (4 months); popcorn, sweet corn, soybean, and potato (10 months). Possible hybrid sensitivity. REI: 12-hour. PHI: 45-day.

**Roundup PowerMax® or Roundup WeatherMax® (glyphosate)** 0.66-3.3 qts. per acre before corn emerges, or 16-22 fl. oz. per acre after corn has emerged. *Roundup Ready® sweet corn only. Other corn will be killed.* May be tank-mixed with several preemergence or postemergence herbicides labeled for corn. Use of other herbicides with residual activity is recommended if Roundup® is used. Postemergence applications may be made over the top of corn through the 8 leaf-collar stage (V-8) or until corn is 30 inches tall. Drop nozzles are recommended if corn is more than 24 inches tall, and must be used if corn is more than 30 inches

tall to prevent spraying into whorls. Do not apply to corn more than 30 inches tall or if it has reached the reproductive stage. Do not exceed 3.3 qts. per acre prior to crop emergence. Do not exceed 44 fl. oz. per acre in a single application in the crop. Do not exceed 4.1 qts. per acre per growing season from emergence through crop height of 48 inches. Do not exceed 5.3 qts. per acre for all applications. REI: 4-hour. PHI: 30-day.

**Shieldex 400SC® (tolpyralate)** 1-1.35 fl. oz. per acre. Apply as a broadcast spray over corn when weeds are small. Apply to corn up to 20 inches tall and showing no more than 6 leaf collars. Controls many broadleaves and grasses. Use higher rate for larger weeds. Add NIS or COC. Many vegetables have 9 month rotational restrictions. Do not exceed 2 applications per year. REI: 12-hour. PHI: 35-day.

### **Postemergence Broadleaf Weeds**

**2,4-D formulations (2,4-D)** 4L amine formulations at 0.5-1.5 pts. per acre. Use lower rates on annual weeds and higher rates on perennial weeds in the bud stage. Use drop nozzles if corn is more than 8 inches tall. Do not apply to open whorls or from 2 week before tasseling through harvest. Avoid drift onto other vegetable crops. Can cause severe injury to some varieties. REI: 48-hour. PHI: 45-day.

**Aim EC® (carfentrazone)** 0.5-2.0 fl. oz. per acre. Apply to actively growing weeds up to 4 in. tall from prior to planting up to V-14 stage. To reduce injury, use drop nozzles to make applications in corn from V8-V14 stages or apply with a hooded-sprayer to minimize application to the whorl. Add 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Do not exceed 2 fl. oz. per acre per season. REI: 12-hour.

**Anthem ATZ® (atrazine, pyroxasulfone, fluthiacet-methyl)** See recommendations in the Preemergence Broadleaf and Grass Weeds section of this chapter.

**Anthem Maxx® (pyroxasulfone, fluthiacet-methyl)** See recommendations in the Preemergence Broadleaf and Grass Weeds section of this chapter.

**Armezon® (topramezone)** 0.5 to 1.0 fl. oz. per acre. Add MSO or COC and urea ammonium nitrate (UAN), ammonium phosphate (10-34-0), or ammonium sulfate. See label for additive rates. Not recommended if products containing mesotrione have been or will be applied to crop. REI: 12-hour. PHI: 45-day.

**bentazon formulations (bentazon)** Use 4L formulations at 1.5-2 pt. per acre and 5L formulations at 1.2 to 1.6 pts. per acre. Add 1 qt. of COC per 25 gals.

spray solution (1% v/v). Apply to small weeds. Also controls nutsedge. Do not apply to corn that is stressed because injury may result. Combine with atrazine to broaden weed control spectrum. Do not exceed 2 lbs. of bentazon (4 pts. of 4L formulation) per acre, per season. REI: 48-hour.

**Cadet® (fluthiacet-methyl)** 0.6-0.9 fl. oz. per acre. For processing sweet corn only. Apply from 2 collars to tasseling. Controls velvetleaf and several other broadleaves. May be tank-mixed with labeled postemergence herbicides. Add COC or NIS. Do not exceed 1.25 fl. oz. per acre per year. REI: 12-hour. PHI: 40-day.

**Callisto® (mesotrione)** See recommendations in the Preemergence Broadleaf Weeds section of this chapter.

**Callisto Xtra® (mesotrione, atrazine)** 20-24 fl. oz. per acre. Apply with 8 fl. oz. of NIS or 1 qt. of COC per 25 gals. spray solution. Apply after corn emerges and before corn is 12 inches tall. Also controls large crabgrass. Cultivars differ in sensitivity to this herbicide; get information on cultivars prior to use. Do not use on corn previously treated with Lorsban® or Counter® insecticides, or within 7 days of treatment with any organophosphate or carbamate insecticide. Contains 0.5 lb. of mesotrione and 3.2 lbs. of atrazine per gal. Do not exceed 0.24 lb. mesotrione or 2.5 lbs. atrazine per acre per year from all sources. Maximum one application per year. REI: 12-hour. PHI: 45-day. RUP.

**halosulfuron formulations (halosulfuron)** See recommendations in the Preemergence Broadleaf Weeds section of this chapter.

**Starane Ultra® (fluroxypyr)** 0.4 pt. per acre. Apply broadcast or as a directed spray to corn that has up to 4 fully exposed leaf collars. Use directed spray when corn is beyond the 4-leaf collar stage. For volunteer potato, can apply preplant to emerged potato followed by a second application postemergence to emerged potato. REI: 24-hour. PHI: 31-day.

**Stinger® (clopyralid)** 0.33-0.66 pt. per acre. Spray on actively growing weeds before corn is 18 inches tall. Controls primarily composites and nightshade. Wait 21 days between applications. Do not exceed 0.66 pt. per crop per year. REI: 12-hour. PHI: 30-day.

### **Postemergence Grass**

**Poast® (sethoxydim)** 0.75-1.5 pt. per acre. *Poast Protected® sweet corn varieties only; will kill other varieties.* Poast Protected® varieties are clearly labeled. Add 1 qt. COC or MSO per 25 gal. of

spray solution (1% v/v). UAN or AMS are optional, see label. Allow at least 10 days between repeated applications. Do not exceed 3 pt. per acre per growing season. Poast Plus® may be used instead at 1.5-2.25 pt. per acre, not to exceed 4.5 pt. per acre per growing season. REI: 12-hour. PHI: 30-day.

## Insect Control

### Recommended Controls

#### Aphids

**Conserve or introduce natural enemies** Heavy corn leaf aphid infestations are often limited to early-season plantings that develop on late whorl to early tassel sweet corn. During this time, several beneficial organisms (including lady beetles, minute pirate bugs, and parasitoids) will keep those infestations in check.

**Assail 30SG® (acetamiprid)** 2.1-2.9 oz. per acre. Do not exceed 4 applications per season. REI: 12-hour. PHI: 1-day.

**Capture LFR® (bifenthrin)** 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. *RUP*.

**Lannate LV® (methomyl)** 0.75-1.5 pts. per acre. Do not exceed 21 pts. per acre per crop. REI: 48-hour. PHI: 0-day for ears, 3-day for forage. *RUP*.

#### Armyworm Caterpillars

Moths being caught in pheromone traps or larval damage present when corn is in late whorl stage.

**Ambush® (permethrin)** 6.4-12.8 fl. oz. per acre. Do not exceed 76 fl. oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Besiege® (chlorantraniliprole, lambda-cyhalothrin)** 6-10 fl. oz. per acre. Do not exceed 31 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

**Capture LFR® (bifenthrin)** Soil: 0.2-0.78 fl. oz. per acre per 1,000 linear ft. row at planting. See label. Foliar: 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: For foliar applications, 1-day. *RUP*.

**Coragen® (chlorantraniliprole)** 3.5-7.5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Entrust SC® (spinosad)** 1.5-6 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. Also see labels for Entrust WP®. Observe resistance management restrictions. The only cutworm labeled is the western bean cutworm. REI: 4-hour. PHI: 1-day. *OMRI-listed*.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. *RUP*.

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Radiant 1SC® (spinetoram)** 3-6 fl. oz. per acre. Do not exceed 36 fl. oz. per acre per season. Do not make applications less than 4 days apart. The only cutworm labeled is the western bean cutworm. REI: 4-hour. PHI: 1-day.

**Sevin XLR Plus® (carbaryl)** 2 qts. per acre. Do not exceed 8 applications or 16 qts. per acre per season. Machine harvest only. REI: 12-hour. PHI: 2-day.

**Tundra EC® (bifenthrin)** Soil: 0.30-0.75 fl. oz. per 1,000 linear feet of row at planting. See label. Foliar: 2.1-6.4 fl. oz. per acre. Do not apply more than 0.2 lb. a.i. per acre per season. Do not apply more than 12.8 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day for soil applications, 1-day for foliar applications. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

#### Corn Earworm/Fruitworm Caterpillar

Corn earworms can be monitored with pheromone traps. When moths are being caught in the traps, it means they are laying eggs. Corn earworm moths lay their eggs directly on green silks. The larvae that hatch from those eggs will follow the silks down into the tips of the ears. Corn earworms must be controlled by directing sprays at the silks so larvae will immediately contact the insecticide after hatching.

For corn earworms, treatment is justified if fresh green silks are present and moths are being caught in pheromone traps. In general, the higher the moth catches, the shorter the interval between sprays. If fewer than five moths are being caught per night, a five-day spray interval should be adequate. As moth catches approach 50 to 100 per night, a two- to three-day spray interval would be more appropriate. Determining the spray interval exactly depends on many factors, including how much damage you can tolerate, the crop's value, and

the cost and effectiveness of the insecticide. Stop treating for corn earworms when 90 percent of the silks are brown. Do not treat separately for European corn borer and corn earworm

More than 10 moths per night in pheromone traps while green silks are present. If no field corn in the area is silking moths will lay eggs primarily on silking sweet corn. In this situation, use a threshold of 1-3 moths per pheromone trap per night.

**Ambush® (permethrin)** 6.4-12.8 fl. oz. per acre. Do not exceed 76 fl. oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Asana XL® (esfenvalerate)** 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Besiege® (chlorantraniliprole, lambda-cyhalothrin)** 6-10 fl. oz. per acre. Do not exceed 31 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

**Capture LFR® (bifenthrin)** Soil: 0.2-0.78 fl. oz. per acre per 1,000 linear ft. row at planting. See label. Foliar: 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: For foliar applications, 1-day. *RUP*.

**Coragen® (chlorantraniliprole)** 3.5-7.5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Entrust SC® (spinosad)** 1.5-6 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. Also see labels for Entrust WP®. Observe resistance management restrictions. The only cutworm labeled is the western bean cutworm. REI: 4-hour. PHI: 1-day. *OMRI-listed*.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. *RUP*.

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Radiant 1SC® (spinetoram)** 3-6 fl. oz. per acre. Do not exceed 36 fl. oz. per acre per season. Do not make applications less than 4 days apart. The only cutworm labeled is the western bean cutworm. REI: 4-hour. PHI: 1-day.

*OMRI-listed* indicates that the product is listed by the Organic Materials Review Institute ([OMRI.org](http://OMRI.org)) and therefore may be acceptable for use in organic production. Check with your certifier before use.

**Sevin XLR Plus® (carbaryl)** 2 qts. per acre. Do not exceed 8 applications or 16 qts. per acre per season. Machine harvest only. REI: 12-hour. PHI: 2-day.

**Tundra EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not apply more than 12.8 fl. oz. per acre per season. REI: 12-hour. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

### **Corn Rootworm Beetles**

If few or no rootworm beetles were present in the field in the previous year, or you grew sweet corn in a field the previous year and followed a regular spray schedule during silking, there is little chance of a damaging infestation.

If you grew sweet corn in a field the previous year and followed a regular spray schedule during silking, then there is little chance of a damaging infestation.

Corn rootworm adults may prevent pollination by feeding on green silks. Treat when silks are being clipped.

**Ambush® (permethrin)** 6.4-12.8 fl. oz. per acre. Do not exceed 76 fl. oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Besiege® (chlorantraniliprole, lambda-cyhalothrin)** 6-10 fl. oz. per acre. Do not exceed 31 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

**Capture LFR® (bifenthrin)** Soil: 0.2-0.78 fl. oz. per acre per 1,000 linear ft. row at planting. See label. Foliar: 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: For foliar applications, 1-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. *RUP*.

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Sevin XLR Plus® (carbaryl)** 2 qts. per acre. Do not exceed 8 applications or 16 qts. per acre per season. Machine harvest only. REI: 12-hour. PHI: 2-day.

**Tundra EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not apply more than 12.8 fl. oz. per acre per season. REI: 12-hour. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

### **Corn Rootworm Larvae**

If few or no rootworm beetles were present in the field in the previous year, or you grew sweet corn in a field the previous year and followed a regular spray schedule during silking, there is little chance of a damaging infestation.

If you grew sweet corn in a field the previous year and followed a regular spray schedule during silking, then there is little chance of a damaging infestation.

Corn rootworm adults may prevent pollination by feeding on green silks. Treat when silks are being clipped.

**Aztec 2.1G® (cyfluthrin, phostebupirim)** 6.7 oz. per 1,000 linear ft. of row. Apply in furrow in a 7-inch band over the row and behind the planter shoe in front of the press wheel. Incorporate with tines and drag chains. REI: 48-hour. *RUP*.

**Brigade 2EC® (bifenthrin)** 0.3 fl. oz. per 1,000 linear ft. of row. Apply in a minimum of 3 gals. of finishes spray as a 5- to 7-inch band over an open seed furrow (T-band). Do not exceed 0.1 lb. a.i. per acre per season at plant application. REI: 12-hour. PHI: 30-day. *RUP*.

**Capture LFR® (bifenthrin)** 0.39-0.98 fl. oz. per 1,000 linear ft. of row. Apply at planting. Apply in furrow or T-band. See label. REI: 12-hour. *RUP*.

**Counter 15G® (terbufos)** 6-8 oz. per 1,000 linear ft. of row. Do not exceed 1 application per acre per crop. REI: 48-hour. *RUP*.

**Ethos 3D® (bifenthrin, Bacillus amyloliquefaciens strain D-747)** 0.52 to 1.05 fl. oz. per 1,000 square feet Must be applied with a 3RIVE 3D system. REI: 12-hour. *RUP*.

**Force CS® (tefluthrin)** 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply at planting. Apply as T-band or in furrow. See label. Do not exceed 1 application per crop. REI: 12-hour. *RUP*.

**Lorsban 15G® (chloryrifos)** 8 oz. per 1,000 linear ft. of row. Apply as T-band over an open seed furrow behind the planter shoe and ahead of the press wheel. Do not exceed 13 lbs. per acre per crop. REI: see label.

**Mocap 15G® (ethoprop)** 8 oz. per 1,000 linear ft. of row. Apply in band over closed seed furrow and incorporate with tines or drag chains. Do not place in the furrow or in direct contact with the seed. Do not exceed 1 application per acre per crop. REI: 48-hour. *RUP*.

**Thimet 20G® (phorate)** 4.5-6 oz. per 1,000 linear ft. of row. Place in a 7-inch band over the row behind the planter shoe and in front of or behind the press wheel and lightly incorporate. REI: 48-hour. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 0.33 oz. per 1,000 linear ft. of row. Apply in furrow or as a 5- to 7-inch band. Do not exceed 30.72 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

### **Cutworm Caterpillars**

**Ambush® (permethrin)** 6.4-12.8 fl. oz. per acre. Do not exceed 76 fl. oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Asana XL® (esfenvalerate)** 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** 0.8-1.6 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Besiege® (chlorantraniliprole, lambda-cyhalothrin)** 6-10 fl. oz. per acre. Do not exceed 31 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

**Blackhawk® (spinosad)** 1.67 to 3.3 fl. oz. per acre. Western bean cutworm only. See label. REI: 4-hour. PHI: 1-day.

**Capture LFR® (bifenthrin)** Soil: 0.2-0.78 fl. oz. per acre per 1,000 linear ft. row at planting. See label. Foliar: 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: For foliar applications, 1-day. *RUP*.

**Coragen® (chlorantraniliprole)** 3.5-7.5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Entrust SC® (spinosad)** 1.5-6 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. Also see labels for Entrust® WP. Observe resistance management restrictions. The only cutworm labeled is the western bean cutworm. REI: 4-hour. PHI: 1-day. *OMRI-listed*.

**Force CS® (tefluthrin)** 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply at planting. Apply as T-band or in furrow. See label. Do not exceed 1 application per crop. REI: 12-hour. *RUP*.

**Lorsban 4E® (chlorpyrifos)** 1-2 pts. per acre. Most effective when soil is moist. If ground is dry, cloddy, or crusty, shallow incorporation before (or soon after) treatment may improve control. REI: see label. PHI: 21-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. *RUP*.

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Radiant 1SC® (spinetoram)** 3-6 fl. oz. per acre. Do not exceed 36 fl. oz. per acre per season. Do not make applications less than 4 days apart. The only cutworm labeled is the western bean cutworm. REI: 4-hour. PHI: 1-day.

**Sevin XLR Plus® (carbaryl)** 2 qts. per acre. Do not exceed 8 applications or 16 qts. per acre per season. Machine harvest only. REI: 12-hour. PHI: 2-day.

**Tundra EC® (bifenthrin)** Soil: 0.30-0.75 fl. oz. per 1,000 linear feet of row at planting. See label. Foliar: 2.1-6.4 fl. oz. per acre. Do not apply more than 0.2 lb. a.i. per acre per season. Do not apply more than 12.8 fl. oz. per acre per season. REI: 12-hour. PHI: 30-day for soil applications, 1-day for foliar applications. *RUP*.

**Warrior II® (lambda-cyhalothrin)** Soil: 0.33 fl. oz. per 1,000 ft. of row. Foliar: 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. REI: 24-hour. PHI: 21-day for soil applications, 1-day for foliar applications. *RUP*.

### **European Corn Borer Caterpillar**

European corn borers can be monitored effectively with blacklight traps and field observations. When moths are being caught in the traps, it means they are laying eggs. Corn borer eggs are laid on leaves, usually on the undersides, in the region of the ear. Larvae feed on the leaves and later may migrate to the ears (if present). Corn borers can be controlled by spraying during the late whorl, tasseling, and silking stages. The migrating larvae should contact a lethal dose of insecticide while moving to the ear zone.

More than 10 moths per night in black light traps while corn is in late whorl stage.

For corn borers, treat during the late whorl stage if 20 percent or more of the plants show larval feeding. The presence of large numbers of moths in light traps also justifies treatment. One application during the late whorl

stage, followed by additional treatments every five days up until seven days of harvest, usually provides adequate control.

**Ambush® (permethrin)** 6.4-12.8 fl. oz. per acre. Do not exceed 76 fl. oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Besiege® (chlorantraniliprole, lambda-cyhalothrin)** 6-10 fl. oz. per acre. Do not exceed 31 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

**Capture LFR® (bifenthrin)** Soil: 0.2-0.78 fl. oz. per acre per 1,000 linear ft. row at planting. See label. Foliar: 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: For foliar applications, 1-day. *RUP*.

**Coragen® (chlorantraniliprole)** 3.5-7.5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. REI: 4-hour. PHI: 1-day.

**Entrust SC® (spinosad)** 1.5-6 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. Also see labels for Entrust WP®. Observe resistance management restrictions. The only cutworm labeled is the western bean cutworm. REI: 4-hour. PHI: 1-day. *OMRI-listed*.

**Larvin® (thiodicarb)** 20-40 fl. oz. per acre. Do not exceed 300 fl. oz. per acre per season. REI: 48-hour. PHI: 0-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. *RUP*.

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Radiant 1SC® (spinetoram)** 3-6 fl. oz. per acre. Do not exceed 36 fl. oz. per acre per season. Do not make applications less than 4 days apart. The only cutworm labeled is the western bean cutworm. REI: 4-hour. PHI: 1-day.

**Sevin XLR Plus® (carbaryl)** 2 qts. per acre. Do not exceed 8 applications or 16 qts. per acre per season. Machine harvest only. REI: 12-hour. PHI: 2-day.

**Tundra EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not apply more than 12.8 fl. oz. per acre per season. REI: 12-hour. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

### Flea Beetles

**Variety selection** Plant varieties that are resistant to Stewart's wilt, which is vectored by flea beetles.

**Ambush® (permethrin)** 6.4-12.8 fl. oz. per acre. Do not exceed 76 fl. oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Asana XL® (esfenvalerate)** 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Baythroid XL® (beta-cyfluthrin)** 0.8-1.6 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Besiege® (chlorantraniliprole, lambda-cyhalothrin)** 6-10 fl. oz. per acre. Do not exceed 31 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

**Capture LFR® (bifenthrin)** 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. *RUP*.

**Lannate LV® (methomyl)** 0.75-1.5 pts. per acre. Do not exceed 21 pts. per acre per crop. REI: 48-hour. PHI: 0-day for ears, 3-day for forage. *RUP*.

**Lorsban 4E® (chlorpyrifos)** 1-2 pts. per acre. Do not exceed 15 pts. per acre per crop. REI: see label. PHI: 21-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 3-day. *RUP*.

**Pounce 25WP® (permethrin)** 6.4-12.8 oz. per acre. Do not exceed 51.2 oz. per acre per season. Control is poor when temperatures are above 90°F. REI: 12-hour. PHI: 1-day. *RUP*.

**Sevin XLR Plus® (carbaryl)** 2 qts. per acre. Do not exceed 8 applications or 16 qts. per acre per season. Machine harvest only. REI: 12-hour. PHI: 2-day.

**Tundra EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not apply more than 12.8 fl. oz. per acre per season. REI: 12-hour. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

### Seed and Root Maggots

**Aztec 2.1G® (cyfluthrin, phostebupirim)** 6.7 oz. per 1,000 linear ft. of row. Apply in furrow in a 7-inch band over the row and behind the planter shoe in front of the press wheel. Incorporate with tines and drag chains. REI: 48-hour. *RUP*.

**Brigade 2EC® (bifenthrin)** 0.3 fl. oz. per 1,000 ft. of row. Apply in a minimum of 3 gals. of finishes spray as a 5- to 7-inch band over an open seed furrow (T-band). Do not exceed 6.4 fl. oz. per acre per season at plant application REI: 12-hour. PHI: 30-day. *RUP*.

**Capture LFR® (bifenthrin)** 0.2-0.78 fl. oz. per 1,000 linear bed ft. of row. Apply at planting. See label. REI: 12-hour. *RUP*.

**Ethos 3D® (bifenthrin, Bacillus amyloloiquefaciens strain D-747)** 0.21 to 1.05 fl. oz. per 1,000 linear feet of row. REI: 12-hour. *RUP*.

**Force CS® (tefluthrin)** 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply at planting. Apply as T-band or in furrow. See label. Do not exceed 1 application per crop. REI: 12-hour. *RUP*.

**Lorsban 15G® (chlorpyrifos)** 8 oz. per 1,000 linear ft. of row. Apply as T-band over an open seed furrow behind the planter shoe and ahead of the press wheel. Do not exceed 13 lbs. per acre per crop. REI: see label.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** Plant seed that has been treated with an insecticide prior to planting. Although most sweet corn seed has been treat with fungicide, it is seldom treated with an insecticide to prevent seed and seedling damage. Use diazinon, Cruiser®, or Poncho®. Follow label directions.

**Tundra EC® (bifenthrin)** 0.15-0.6 fl. oz. per 1,000 linear feet of row. Apply at planting. See label. REI: 12-hour. PHI: 30-day. *RUP*.

### Seedcorn Beetles

**Aztec 2.1G® (cyfluthrin, phostebupirim)** 6.7 oz. per 1,000 linear ft. of row. Apply in furrow in a 7-inch band over the row and behind the planter shoe in front of the press wheel. Incorporate with tines and drag chains. REI: 48-hour. *RUP*.

**Brigade 2EC® (bifenthrin)** 0.3 fl. oz. per 1,000 ft. of row. Apply in a minimum of 3 gals. of finishes spray as a 5- to 7-inch band over an open seed furrow (T-band). Do not exceed 6.4 fl. oz. per acre per season at plant application REI: 12-hour. PHI: 30-day. *RUP*.

**Capture LFR® (bifenthrin)** 0.2-0.78 fl. oz. per 1,000 linear bed ft. of row. Apply at planting. See label. REI: 12-hour. *RUP*.

**Force CS® (tefluthrin)** 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply at planting. Apply as T-band or in furrow. See label. Do not exceed 1 application per crop. REI: 12-hour. *RUP*.

**Lorsban 15G® (chlorpyrifos)** 8 oz. per 1,000 linear ft. of row. Apply as T-band over an open seed furrow behind the planter shoe and ahead of the press wheel. Do not exceed 13 lbs. per acre per crop. REI: see label.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** Plant seed that has been treated with an insecticide prior to planting. Although most sweet corn seed has been treated with fungicide, it is seldom treated with an insecticide to prevent seed and seedling damage. Use diazinon, Cruiser®, or Poncho®. Follow label directions.

**Tundra EC® (bifenthrin)** 0.15-0.6 fl. oz. per 1,000 linear feet of row. Apply at planting. See label. REI: 12-hour. PHI: 30-day. *RUP*.

### **Stink Bugs**

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Besiege® (chlorantraniliprole, lambda-cyhalothrin)** 6-10 fl. oz. per acre. Do not exceed 31 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

**Capture LFR® (bifenthrin)** 2.8-8.5 fl. oz. per acre. REI: 12-hour. PHI: 1-day. *RUP*.

**Hero® (bifenthrin, zeta-cypermethrin)** 4-10.3 fl. oz. per acre. Do not exceed 27.39 fl. oz. per acre per season. Allow 3 days between applications. REI: 12-hour. PHI: 3-day. *RUP*.

**Lannate LV® (methomyl)** 0.75-1.5 pts. per acre. Brown Marmorated Stink Bug only. Do not exceed 21 pts. per acre per crop. REI: 48-hour. PHI: 0-day PHI for ears, 3-day PHI for forage. *RUP*.

**Tundra EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Do not apply more than 12.8 fl. oz. per acre per season. REI: 12-hour. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. REI: 24-hour. PHI: 1-day. *RUP*.

### **Wireworms**

**Aztec 2.1G® (cyfluthrin, phostebupirim)** 6.7 oz. per 1,000 linear ft. of row. Apply in furrow in a 7-inch band over the row and behind the planter shoe in front of the press wheel. Incorporate with tines and drag chains. REI: 48-hour. *RUP*.

**Brigade 2EC® (bifenthrin)** 0.3 fl. oz. per 1,000 ft. of row. Apply in a minimum of 3 gals. of finishes spray as a 5- to 7-inch band over an open seed furrow (T-band). Do not exceed 6.4 fl. oz. per acre per season at plant application REI: 12-hour. PHI: 30-day. *RUP*.

**Capture LFR® (bifenthrin)** 0.2-0.78 fl. oz. per 1,000 linear bed ft. of row. Apply at planting. See label. REI: 12-hour. *RUP*.

**Force CS (tefluthrin)** 0.46-0.57 fl. oz. per 1,000 linear ft. of row. Apply at planting. Apply as T-band or in furrow. See label. Do not exceed 1 application per crop. REI: 12-hour. *RUP*.

**Seed treatments (thiamethoxam, mefenoxam, fludioxonil, azoxystrobin, thiabendazole, spinosad, abamectin)** Plant seed that has been treated with an insecticide prior to planting. Although most sweet corn seed has been treated with fungicide, it is seldom treated with an insecticide to prevent seed and seedling damage. Use diazinon, Cruiser, or Poncho. Follow label directions.

**Tundra EC® (bifenthrin)** 0.15-0.6 fl. oz. per 1,000 linear feet of row. Apply at planting. See label. REI: 12-hour. PHI: 30-day. *RUP*.

# Sweet Potato

<b>Varieties</b>	
Beauregard	Early, light red skin, orange flesh, consistent yield, high quality, resistant to Fusarium wilt, intermediately resistant to resistant to streptomyces soil rot, increasingly popular
Centennial	Soft-fleshed type, orange skin
Covington	Orange-fleshed, smooth-skinned, rose-colored, 5-10 days later than Beauregard. Resistant to Fusarium wilt, southern root-knot nematode, and moderately resistant to streptomyces soil rot.
Evangeline	Orange-flesh, produces fewer oversized or jumbo grade roots, southern root-knot nematode resistance, higher sucrose content
Hernandez	Copper skin, deep orange flesh
Nugget	Firm-fleshed type, orange skin, orange flesh, good quality, excellent keeper
Orleans	Orange-flesh, light rose-skin, superior shape, yields are equal to 'Beauregard,' resistant to Fusarium wilt, intermediate resistance to streptomyces soil rot
<b>For Trial</b>	
Carolina Ruby	Dark red skin; orange flesh; consistent yields for early-, middle-, or late-season planting; resistant to Fusarium wilt; excellent keeper

## Plant Production

Select seed stock from high-yielding hills that are smooth, well-shaped, and free of diseases (scurf, internal cork, wilt, black rot) and insect injury. When possible, obtain certified G1 or G2 (generation) seed stock. Store seed stock in new crates to avoid disease contamination. Seed potatoes should be at least 1.5 inches in diameter. One bushel of small- to medium-sized roots should produce 500 to 800 sprouts in 10-15 square feet of bed area (one cut).

Slip/cutting production should be in movable protected system (low/high tunnels) for early planting in the field to maximize production season. Before bedding, seed stock should be pre-sprouted at 85°F and 90% relative humidity for 3-4 weeks until the sprouts are 1-1½ inch. Treat seed before planting with Mertect 340-F® to protect roots from certain soil-borne diseases. Bed the seed stock in clean land that has not been with sweet potato for 4

years. Optimal temperature for growth is 75°F to 85°F. Remove tunnels 7 days prior to planting to harden the slips.

## Planting and Spacing

Transplanting machines are available for mechanically planting sweet potato slips. Common spacing is 1 foot apart in the row, with rows 3 to 4 feet apart, depending upon the cultivating and harvesting equipment used. 14,520 slips per acre are required at the 1 foot by 3 feet spacing, while 10,890 are needed at the 1 foot by 4 feet spacing. Transplant only strong, stocky slips. Yields can be increased up to 100 bushels per acre by using strong transplants.

## Fertilizing

**Lime:** None usually necessary. Soil pH of 5.0 to 6.0 is satisfactory.

**Preplant:** N: 30 pounds per acre. P<sub>2</sub>O<sub>5</sub>: 0 to 75 pounds per acre. K<sub>2</sub>O: 0 to 250 pounds per acre. Adjust according to soil type, previous management, and soil test results for your state. Set the slips with a starter solution at the rate of 1 cup (8 ounces) per plant.

**Sidedress N:** None usually necessary on finer textured soils. On irrigated sands, sidedress with 30 to 50 pounds N per acre approximately 3 to 4 weeks after transplanting.

## Harvesting

Remove vines by cutting with a rotary mower 5 to 7 days before harvest to toughen the skin. Dig only those potatoes that can be picked up immediately and not left out overnight. Temperatures below 55°F can chill potatoes and cause internal breakdown in storage. Potatoes will sunburn if left in direct sunlight for more than an hour. To prevent skinning and bruising use cotton gloves when placing potatoes in crates. Field grading is important.

## Curing and storing

Cure sweet potatoes immediately at 85°F and 85% to 90% humidity for 5 to 7 days. After curing, the temperature may be gradually dropped to 58°F. Hold this temperature until potatoes are marketed or used for producing slips.

## Disease Control

### Recommended Controls

#### **Black Rot of Sweet Potatoes - *Ceratocystis* Fungus**

Plant disease-free seed and/or resistant varieties. Follow 3-4 year crop rotations. Prevent bruising and maintain proper storage temperatures.

**Crop rotation** Rotate between crop families to reduce disease inoculum buildup.

**Mertect 340F® (thiabendazole)** 8 fl. oz. per 7.5 gal. of water. One application only. REI: see label. PHI: 0-day.

#### **Foot Rot of Sweet Potatoes - *Plenodomus* Fungus**

Plant disease-free seed and/or resistant varieties. Follow 3-4 year crop rotations. Prevent bruising and maintain proper storage temperatures.

**Crop rotation** Rotate between crop families to reduce disease inoculum buildup.

**Mertect 340F® (thiabendazole)** 8 fl. oz. per 7.5 gal. of water. One application only. REI: see label. PHI: 0-day.

#### **Scurf of Sweet Potatoes - *Monilochaetes* Fungus**

Plant disease-free seed and/or resistant varieties. Follow 3-4 year crop rotations. Prevent bruising and maintain proper storage temperatures.

**Crop rotation** Rotate between crop families to reduce disease inoculum buildup.

**Botran 75W® (dichloro-nitroaniline)** Use as seed potato dip or plant bed spray. REI: see label. PHI: 0-day.

**Mertect 340F® (thiabendazole)** 8 fl. oz. per 7.5 gal. of water. One application only. REI: see label. PHI: 0-day.

#### **Storage Rots of Sweet Potato**

**Sanitation** Fumigate storage boxes. Cure and store only healthy, blemish-free tubers.

#### **Wilt of Multiple Crops - *Fusarium* Fungus**

Plant disease-free seed and/or resistant varieties. Follow 3-4 year crop rotations. Prevent bruising and maintain proper storage temperatures.

**Crop rotation** Rotate between crop families to reduce disease inoculum buildup.

## Weed Control

Sweet potatoes are often grown on black plastic mulch because they benefit from the higher soil temperature it provides early in the season. The mulch also provides weed control near the row. Between rows, cultivation and hand hoeing are typically used until the sweet potato vines cover the soil. A few herbicides are available for use in sweet potato.

For specific weeds controlled by each herbicide, check Relative Effectiveness of Herbicides for Vegetable Crops table.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

The critical period for weed control in sweet potato is 2-6 weeks after transplanting.

### Recommended Controls

#### **Burndown or Directed/Shielded Application**

##### **Broadleaf and Grass Weeds**

**glyphosate formulations (glyphosate)** 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations of 3 lbs. ae per gal. (4 lbs. isopropylamine salt per gal.) at 1-5 qt. per acre or formulations containing 4.5 lbs. ae per gal. (5 lbs. potassium salt per gal.) at 0.66-3.3 qt. per acre. Broadcast before planting, or apply with wipers or hooded or shielded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. REI: 4-hour. PHI: 14-day for foliar applications directed between rows, 7-day for wiper applications.

**paraquat formulations (paraquat)** 1-2 pt. of 2 lb. per gal. formulations. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS (0.25% v/v) per 25 gal. of solution and apply to emerged weeds less than 6 inches tall prior to transplanting.

Certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat. REI: 24-hour. RUP.

#### **Premeregence Broadleaf and Grass Weeds**

**Command 3ME® (clomazone)** 1.4-4.0 pt. per acre. Use low rate on coarse soils. Apply in a single application immediately after transplanting and before weeds emerge. When used alone may not adequately control pigweed species and does not control carpetweed. REI: 12-hour. PHI: 95-day for rates up to 3.3 pt. per acre, 125-day for rates over 3.3 pt. per acre.

**Devrinol DF-XT® (napropamide)** 2-4 lbs. per acre. Apply immediately after transplanting. If rain does not occur within 24 hours, incorporate shallowly or irrigate with 0.5 inch of water. REI: 24-hour.

**Dual Magnum® (s-metolachlor)** 1.0-1.3 pts. per acre. *Illinois, Indiana, Michigan and Missouri only - applicators must have 24c label. Illinois label expires March 25, 2024. Michigan label expires December 31, 2021.* Apply after transplanting before weeds emerge. Do not incorporate into soil. Close transplant trenches before application. Dual Magnum® applied shortly after transplanting and followed by moderate to heavy rainfall or irrigation can result in reduced yields and misshapen storage roots. Crop safety is improved by 10-14 days after transplanting when Dual Magnum® can be used as a layby application prior to canopy closure. REI: 24-hour. PHI: 60-day.

### **Preemergence Broadleaf Weeds**

**Valor SX® (flumioxazin)** 2-3 oz. per acre. Apply to prepared planting beds prior to transplanting. Do not use on greenhouse-grown transplants or on transplants harvested more than 2 days before transplanting. Do not use on varieties other than Beauregard unless you have tested for phytotoxicity under your conditions. REI: 12-hour.

### **Preemergence Grass Weeds**

**Dacthal® (DCPA)** Dacthal W-75® at 6-14 lbs. per acre, or Dacthal Flowable® at 6-14 pts. per acre. Apply at transplanting or at layby up to 6 weeks after transplanting. May be applied over the top of transplants. REI: 12-hour.

### **Postemergence Broadleaf Weeds**

**Aim EC® (carfentrazone)** 0.5-2 fl. oz. per acre. Apply with a hooded sprayer as a directed application between crop rows. Add 1 qt. COC (1% v/v) or 0.5 pt. NIS per 25 gal. of spray solution (0.25% v/v). Weeds must be actively growing and less than 4 in. tall. Do not allow spray to contact crop. Do not exceed 11.6 fl. oz. per acre per season. REI: 12-hour. PHI: 7-day.

### **Postemergence Grass Weeds**

**clethodim formulations (clethodim)** Use 2 lb. per gal. formulations at 6-16 fl. oz. per acre with 1 qt. COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. per acre per season. Use 0.97 lb. per gal. formulations at 9-32 fl. oz. per acre with 0.5 pt. NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. per acre per season. Use low rates for annual grasses and high rates for perennial grasses. Spray on actively growing grass. Wait at least 14 days between applications. REI: 24-hour. PHI: 30-day.

**Fusilade DX® (fluazifop-P)** 10-12 fl. oz. per acre. Add 1 qt. COC (1% v/v) or 0.5 pt. of NIS per 25 gals of spray solution (0.25% v/v). Apply to actively growing grass. Do not exceed 4 applications or 48 fl. oz. per acre per season. REI: 12-hour. PHI: 14-day.

## **Insect Control**

### **Recommended Controls**

#### **Aphids**

**Actara® (thiamethoxam)** 1.5-3.0 oz. per acre. Do not exceed 6 oz. per acre per season. REI: 12-hour. PHI: 14-day.

**Admire Pro® (imidacloprid)** 1.2 fl. oz. per acre foliar application, 4.4-10.5 fl. oz. per acre or 0.26 fl. oz. per 1,000 ft. of row soil application. Do not exceed 10.5 fl. oz. or 1 application per acre per season. REI: 12-hour. PHI: 7-day for foliar applications, or 125-day for soil applications.

**Assail 30SG® (acetamiprid)** 1.5-4.0 oz. per acre. Do not exceed 16 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Baythroid XL® (beta-cyfluthrin)** 2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Belay® (clothianidin)** 2-3 fl. oz. per acre. Foliar application: 2-3 fl. oz. per acre. Preplant broadcast, at-plant in-furrow, or post-plant sidedress application: 9-12 fl. oz. per acre. Do not exceed 12 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Beleaf 50SG® (flonicamid)** 2.0-2.8 oz. per acre. Do not exceed 8.4 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Fulfill® (pyrmetrazine)** 2.75-5.50 oz. per acre. Do not exceed 11 oz. per acre per season. REI: 12-hour. PHI: 14-day.

**Movento® (spirotetramat)** 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day.

**Platinum 2SC® (thiamethoxam)** 5-8 fl. oz. per acre. Apply at planting. Do not exceed 8 fl. oz. per acre per season. REI: 12-hour.

**Sivanto 200SL® (flupyradifurone)** 7.0-10.5 fl. oz. per acre. Apply at planting or as foliar spray. Do not exceed 28 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day.

**Transform WG® (sulfoxaflor)** 1.5-2.75 oz. per acre. Do not exceed 8.5 oz. per acre per season. REI: 24-hour. PHI: 7-day.

**Voliam Flexi® (thiamethoxam, chlorantraniliprole)** 4 oz. per acre. Do not exceed 8 oz. per acre per season. REI: 12-hour. PHI: 14-day.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

### **Armyworm Caterpillars**

**Entrust® (spinosad)** 1.5-3.0 fl. oz. per acre. Do not exceed 6.5 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day. *OMRI-listed*.

**Mustang Maxx® (zeta-cypermethrin)** 1.28-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Radiant 1SC® (spinetoram)** 4.5-8.0 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day.

**Rimon 0.83EC® (novaluron)** 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 14-day.

**Voliam Flexi® (thiamethoxam, chlorantraniliprole)** 4 oz. per acre. Do not exceed 8 oz. per acre per season. REI: 12-hour. PHI: 14-day.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

### **Cucumber Beetles**

**Assail 30SG® (acetamiprid)** 1.5-4.0 oz. per acre. Do not exceed 16 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Foliar application. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. *RUP*.

**Capture LFR® (bifenthrin)** 12.75-25.5 fl. oz. per acre. Apply at planting or layby. Do not exceed 41.67 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** 1.28-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

### **Cutworm Caterpillars**

**Baythroid XL® (beta-cyfluthrin)** 0.8-1.6 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** 1.28-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Warrior II® (lambda-cyhalothrin)** 0.96-1.60 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

### **Flea Beetles**

**Actara® (thiamethoxam)** 1.5-3.0 oz. per acre. Do not exceed 6 oz. per acre per season. Control may require 2 applications at a 7-10 day interval. REI: 12-hour. PHI: 14-day.

**Admire Pro® (imidacloprid)** 1.2 fl. oz. per acre foliar application, 4.4-10.5 fl. oz. per acre or 0.26 fl. oz. per 1,000 ft. of row soil application. Do not exceed 10.5 fl. oz. or 1 application per acre per season. REI: 12-hour. PHI: 7-day for foliar applications, or 125-day for soil applications.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Belay® (clothianidin)** 2-3 fl. oz. per acre. Foliar application: 2-3 fl. oz. per acre. Preplant broadcast, at-plant in-furrow, or post-plant sidedress application: 9-12 fl. oz. per acre. Do not exceed 12 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Brigade 2EC® (bifenthrin)** 2.1-6.4 fl. oz. per acre. Foliar application. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. *RUP*.

**Capture LFR® (bifenthrin)** 12.75-25.5 fl. oz. per acre. Apply at planting or layby. Do not exceed 41.67 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. *RUP*.

**chlorpyrifos formulations (chlorpyrifos)** Use 15G formulations at 13.5 lbs. per acre. Use 75WG formulations at 2.67 lbs. per acre. Use 4E formulations at 4 pts. per acre. Evenly spread granules or spray soil surface preplant and incorporate to a depth of 4-6 inches. Plant sweet potatoes no more than 14 days after treatment. Do not exceed 1 application per season. REI: see label. PHI: 125-day. *RUP*.

**Mustang Maxx® (zeta-cypermethrin)** 1.28-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Platinum 2SC® (thiamethoxam)** 5-8 fl. oz. per acre. Apply at planting. Do not exceed 8 fl. oz. per acre per season. REI: 12-hour.

**Voliam Flexi® (thiamethoxam, chlorantraniliprole)** 4 oz. per acre. Do not exceed 8 oz. per acre per season. REI: 12-hour. PHI: 14-day.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

### **Leafhoppers**

**Actara® (thiamethoxam)** 1.5-3.0 oz. per acre. Do not exceed 6 oz. per acre per season. Control may require 2 applications at a 7-10 day interval. REI: 12-hour. PHI: 14-day.

**Admire Pro® (imidacloprid)** 1.2 fl. oz. per acre foliar application, 4.4-10.5 fl. oz. per acre or 0.26 fl. oz. per 1,000 ft. of row soil application. Do not exceed 10.5 fl. oz. or 1 application per acre per season. REI: 12-hour. PHI: 7-day for foliar applications, or 125-day for soil applications.

**Assail 30SG® (acetamiprid)** 1.5-4.0 oz. per acre. Do not exceed 16 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Baythroid XL® (beta-cyfluthrin)** 0.8-1.6 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Belay® (clothianidin)** 2-3 fl. oz. per acre. Foliar application: 2-3 fl. oz. per acre. Preplant broadcast, at-plant in-furrow, or post-plant sidedress application: 9-12 fl. oz. per acre. Do not exceed 12 fl. oz. per acre. REI: 12-hour. PHI: 14-day.

**Malathion 5EC® (malathion)** 1.5-2.5 pts. per acre. Do not exceed 2.5 pts. per acre per season. REI: see label. PHI: 7-day.

**Mustang Maxx® (zeta-cypermethrin)** 1.28-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Platinum 2SC® (thiamethoxam)** 5-8 fl. oz. per acre. Apply at planting. Do not exceed 8 fl. oz. per acre per season. REI: 12-hour.

**Sivanto 200SL® (flupyradifurone)** 7.0-10.5 fl. oz. per acre. Apply at planting or as foliar spray. Do not exceed 28 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day.

**Transform WG® (sulfoxaflor)** 1.5-2.75 oz. per acre. Do not exceed 8.5 oz. per acre per season. REI: 24-hour. PHI: 7-day.

**Voliam Flexi® (thiamethoxam, chlorantraniliprole)** 4 oz. per acre. Do not exceed 8 oz. per acre per season. REI: 12-hour. PHI: 14-day.

**Warrior II® (lambda-cyhalothrin)** 0.96-1.60 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

### **Looper Caterpillars**

**Avaunt 30WDG® (indoxacarb)** 2.5-6.0 oz. per acre. Do not exceed 24 oz. per acre per season. REI: 12-hour. PHI: 7-day.

**Baythroid XL® (beta-cyfluthrin)** 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. REI: 12-hour. PHI: 0-day. *RUP*.

**Entrust® (spinosad)** 1.5-3.0 fl. oz. per acre. Do not exceed 6.5 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day. *OMRI-listed*.

**Mustang Maxx® (zeta-cypermethrin)** 1.28-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 1-day. *RUP*.

**Radiant 1SC® (spinetoram)** 4.5-8.0 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day.

**Rimon 0.83EC® (novaluron)** 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. REI: 12-hour. PHI: 14-day.

**Voliam Flexi® (thiamethoxam, chlorantraniliprole)** 4 oz. per acre. Do not exceed 8 oz. per acre per season. REI: 12-hour. PHI: 14-day.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP*.

### **Thrips**

**Admire Pro® (imidacloprid)** 4.4-10.5 fl. oz. per acre or 0.26 fl. oz. per 1,000 ft. of row soil application. Do not exceed 10.5 fl. oz. or 1 application per acre per season. REI: 12-hour. PHI: 125-day.

**Entrust® (spinosad)** 1.5-3.0 fl. oz. per acre. Do not exceed 6.5 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day. *OMRI-listed.*

**Radiant 1SC® (spinetoram)** 4.5-8.0 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. REI: 4-hour. PHI: 7-day.

**Warrior II® (lambda-cyhalothrin)** 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. REI: 24-hour. PHI: 7-day. *RUP.*

### **Wireworms**

**Brigade 2EC® (bifenthrin)** 9.6-19.2 fl. oz. per acre. Preplant-incorporated broadcast, directed bed spray, or T-band spray into the planting furrow. Do not exceed 32 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day. *RUP.*

**Capture LFR® (bifenthrin)** 12.75-25.5 fl. oz. per acre. Apply at planting or layby. Do not exceed 41.67 fl. oz. per acre per season. REI: 12-hour. PHI: 21-day, *RUP.*

**chlorpyrifos formulations (chlorpyrifos)** Use 15G formulations at 13.5 lbs. per acre. Use 75WG formulations at 2.67 lbs. per acre. Use 4E formulations at 4 pts. per acre. Evenly spread granules or spray soil surface preplant and incorporate to a depth of 4-6 inches. Plant sweet potatoes no more than 14 days after treatment. Do not exceed 1 application per season. REI: see label. PHI: 125-day. *RUP.*





# Pesticide Emergency and Poison Control Centers

## Nationwide Emergency Number

(800) 222-1222

This number will automatically connect you to the poison center nearest you.

## Illinois

### *Illinois Poison Center*

222 S. Riverside Plaza, Suite 1900  
Chicago, IL 60606

**Emergency Number:** (800) 222-1222

**TDD/TTY:** (312) 906-6185

[www.mchc.org/ ipc](http://www.mchc.org/ ipc)

Personnel at this number will give first aid instructions and direct callers to local treatment centers. For immediate emergency treatment or ambulance service, always call 911.

## Indiana

### *Indiana Poison Center*

1701 N. Senate Ave.  
Indianapolis, IN 46202

**Emergency Number:** (800) 222-1222

**TTY/TDD:** (317) 962-2336

Fax: (317) 962-8295

[indianapoison.org](http://indianapoison.org)

## Iowa

### *Iowa Statewide Poison Control Center*

401 Douglas St., Suite 215  
Sioux City, IA 51101

**Emergency Number:** (800) 222-1222

**To Report Spills:** (515) 725-8694

(also contact local law enforcement)

**TTY:** (800) 222-1222

[www.iowapoison.org](http://www.iowapoison.org)

## Kansas

### *Poison Control Center*

University of Kansas Health System

**Toll free emergency hotline:** (800) 222-1222

[www.kansashealthsystem.com/medical-services/poison-control](http://www.kansashealthsystem.com/medical-services/poison-control)

## Michigan

### *Michigan Regional Poison Control Center*

Children's Hospital of Michigan  
3901 Beaubien St.  
Detroit, MI 48201

**Emergency Number:** (800) 222-1222

**Local Number:** (612) 873-3141

**TTY:** (317) 962-2336

Local Number: (313) 745-5437

For non-emergencies, email [dmcpcc@dmc.org](mailto:dmcpcc@dmc.org)

## Minnesota

### *Minnesota Poison Control System*

Hennepin County Medical Center  
701 Park Avenue, Mail Code RL  
Minneapolis, MN 55415

**Emergency Number:** (800) 222-1222

**Local Number:** (612) 873-3141

**TTY:** (800) 222-1222

[www.mnpoison.org](http://www.mnpoison.org)

## Missouri

### *Missouri Poison Center*

7980 Clayton Road, Suite 200  
St. Louis, MO 63117

**Emergency Number:** (800) 222-1222

**In St. Louis:** (314) 772-5200

**TDD/TTY:** (314) 612-5705

[missouripoisoncenter.org](http://missouripoisoncenter.org)

## Ohio

### *Ohio Poison Exposure Centers*

**Emergency Number:** (800) 222-1222

**TDD:** (800) 253-7955

All calls will be automatically routed to the regional Ohio Poison Exposure Center closest to you.

# Extension Vegetable Crop Production Websites

**Midwest Vegetable Production Guide for Commercial Growers**  
[mwveguide.org](http://mwveguide.org)

**Illinois Fruit & Vegetable IPM**  
[extension.cropsciences.illinois.edu/fruitveg](http://extension.cropsciences.illinois.edu/fruitveg)

**Illinois Fruit & Vegetable News**  
[ipm.illinois.edu/ifvn](http://ipm.illinois.edu/ifvn)

**Iowa State University**  
[www.extension.iastate.edu/vegetablelab](http://www.extension.iastate.edu/vegetablelab)

**K-State Plant Pathology Extension**  
[www.plantpath.k-state.edu/extension](http://www.plantpath.k-state.edu/extension)

**K-State Horticulture Extension**  
[hnr.k-state.edu/extension](http://hnr.k-state.edu/extension)

**Michigan State University Extension Vegetables**  
[www.canr.msu.edu/vegetables](http://www.canr.msu.edu/vegetables)

**Minnesota VegEdge**  
[www.vegedge.umn.edu](http://www.vegedge.umn.edu)

**Ohio VegNet**  
[u.osu.edu/vegnetnews](http://u.osu.edu/vegnetnews)

**Purdue Vegetable Crops Hotline**  
[vegcropshotline.org](http://vegcropshotline.org)

**Purdue Horticulture Extension-Vegetable Crops**  
[ag.purdue.edu/hla/Extension/Pages/Vegetable-Crops.aspx](http://ag.purdue.edu/hla/Extension/Pages/Vegetable-Crops.aspx)

**Radcliffe's IPM World Textbook**  
[ipmworld.umn.edu](http://ipmworld.umn.edu)

**University of Missouri**  
[www.plantsci.missouri.edu](http://www.plantsci.missouri.edu)

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