Stay Current

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

### Abbreviations Used in This Guide

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>PHI</td>
<td>pre-harvest interval — the minimum allowable time in days between the latest pesticide application and crop harvest</td>
</tr>
<tr>
<td>AI</td>
<td>active ingredient</td>
</tr>
<tr>
<td>COC</td>
<td>crop oil concentrate</td>
</tr>
<tr>
<td>D</td>
<td>dust formulation</td>
</tr>
<tr>
<td>DF, DG</td>
<td>dry flowable or water dispersible granule formulation</td>
</tr>
<tr>
<td>E, EC</td>
<td>emulsifiable concentrate</td>
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<tr>
<td>F</td>
<td>flowable formulation</td>
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<tr>
<td>G</td>
<td>granular formulation</td>
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<tr>
<td>L, LC</td>
<td>liquid concentrate formulation</td>
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<tr>
<td>NIS</td>
<td>nonionic surfactant</td>
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<tr>
<td>REI</td>
<td>re-entry interval</td>
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<tr>
<td>RUP</td>
<td>restricted use pesticide</td>
</tr>
<tr>
<td>SC</td>
<td>suspension concentrate</td>
</tr>
<tr>
<td>W, WP</td>
<td>wettable powder formulation</td>
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**Cover photos:** Bees are critical for pollinating vegetable crops such as the watermelon shown here. Information about the placement and number of hives, care of honeybees, and how to safely use insecticides around bees can be found on pages 30-32.

Insect, disease, and weed control recommendations in this publication are valid only for 2017. If registration for any of the chemicals suggested is changed during the year since the time of publication (December 2016), 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 2017

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Photos by the contributors, Brian Christie, Mike Kerper, John Obermeyer, and Elizabeth Wuerffel.
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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.

What’s New in 2017?

Highlights of Changes in This Edition

This year, we welcome Michigan growers and Michigan State University to the Midwest Vegetable Production Guide team. We are glad to add the expertise of MSU specialists. Contact information for Michigan specialists and agricultural-related offices and services are available throughout the guide.

New and Revised Sections

- We added a chapter for Celery — see page 88.
- We added a section called Selected University Laboratory Services (page 46), which includes contact information for each state.
- We revised the organic section to list certifiers on a regional basis.
- We updated the entire Soil Fertility and Nutrient Management section (pages 12-23).

Disease Management

- We updated the Disease Management section (pages 69-77).
- We updated the Orondis® products (Ultra, Opti, and Gold) in the Cucurbit Crops and Fruiting Vegetable chapters.
- The Luna® products Experience and Sensation have had label expansions to include all cucurbits.
- We updated product rating tables in the Cucurbit Crops and Fruiting Vegetables chapters.
- The powdery mildew on tomato section contains updates with several products.

Weed Management

- We added Spartan 4F® and Spur 3L® to the Asparagus chapter.
- The Cole Crops and Fruiting Vegetables chapters now include Prowl H2O® and Stinger®.
- For pumpkins, we added Reflex® for Illinois and Michigan growers only.
- The Fruiting Vegetables chapter now includes Devrinol 50DF-XT®.

Insect Management

- The Asparagus chapter includes several new insect pests.
- We added thresholds for thrips control and insecticide use to the Dry Bulb and Green Bunching Onion, Garlic, and Leek chapter.
- The Cucurbit Crops, Legumes, and Potato chapters include new uses for Sivanto®.
- We added Venom 70SG® to the Cucurbit Crops chapter.
- The Cole Crops and Potato chapters now include Belay 2.13 SC®.
- We removed Synapse® from the guide.
- The registration for Closer® was voided in the summer of 2016, so all recommendations for this product were removed from this guide. However, the registration was restored just before this guide was published. Check the pesticide label for its availability for use on your crops.
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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. For information or to order, contact Nathan Johanning, Local Food Systems and Small Farms Extension Educator at (618) 687-1727 or njohann@illinois.edu. Fact Sheets about vegetable and fruit crops from the University of Illinois are available at extension.cropsci.illinois.edu/fruitveg.
## Indiana

Purdue Extension: extension.purdue.edu

Purdue Horticulture-Vegetable Crops: ag.purdue.edu/hla/Extension/Pages/Vegetable-Crops.aspx

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<td>(219) 326-6808 Fax: (219) 326-7362 <a href="mailto:ematzat@purdue.edu">ematzat@purdue.edu</a></td>
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<tr>
<td>Porter</td>
<td>Lyndsay Ploehn</td>
<td>Purdue Extension-Porter County 155 Indiana Ave., Suite 301 Valparaiso, IN 46383-5549</td>
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<td></td>
</tr>
<tr>
<td>Vanderburgh</td>
<td>Larry Caplan</td>
<td>13301 Darmstadt Road Evansville, IN 47725-9593</td>
<td>(812) 435-5287 Fax: (812) 867-4944 <a href="mailto:lcaplan@purdue.edu">lcaplan@purdue.edu</a></td>
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</table>

**Purdue Extension Vegetable Crops Hotline**

Purdue Extension issues a bi-weekly vegetable newsletter to growers throughout the vegetable growing season at a nominal cost. This newsletter provides timely information on disease and insect activity and management, as well as cultural and post-harvest 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.
## Iowa

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

<table>
<thead>
<tr>
<th>Horticultural/Vegetable Crops Field Specialists</th>
<th>Address</th>
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<tr>
<td><strong>Central/Western</strong></td>
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<tr>
<td>Area</td>
<td>Specialist</td>
<td>Address</td>
</tr>
<tr>
<td>Area</td>
<td>Joe Hannan</td>
<td>Iowa State University Extension 28059 Fairground Road Adel, IA 50003</td>
</tr>
<tr>
<td>Diagnostic Clinic</td>
<td>Laura Jesse, Lina Rodriguez-Salamanca</td>
<td>Iowa State University Plant and Insect Diagnostic Clinic 327 Bessey Hall Iowa State University Ames, IA 50011</td>
</tr>
<tr>
<td>Eastern</td>
<td>Patrick O’Malley</td>
<td>Iowa State University Extension 3109 Old HWY 218 S. Iowa City, IA 52246</td>
</tr>
<tr>
<td>Vegetable Diseases</td>
<td>Lina Rodriguez-Salamanca</td>
<td>Iowa State University 327 Bessey Ames, IA 50011-1100</td>
</tr>
<tr>
<td>Vegetable Insects</td>
<td>Donald Lewis Laura Jesse</td>
<td>Iowa State University 104 Insectary Ames, IA 50011-3140</td>
</tr>
<tr>
<td>Vegetable Production</td>
<td>Ajay Nair</td>
<td>Iowa State University 145 Horticulture Hall Ames, IA 50011</td>
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## Kansas

Kansas State University Research and Extension: [www.ksre.ksu.edu](http://www.ksre.ksu.edu)

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<th>Kansas State Extension Educators</th>
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<tbody>
<tr>
<td>Name</td>
<td>Title and Expertise</td>
<td>K-State Research &amp; Extension Center 35230 W 135th St. Olathe, KS 66061</td>
</tr>
<tr>
<td>Cary Rivard</td>
<td>Assistant Professor and State Extension Specialist, Vegetable and Fruit Production</td>
<td>Department of Entomology 239 W. Waters Hall Kansas State University Manhattan KS 66506</td>
</tr>
<tr>
<td>Raymond Cloyd</td>
<td>Professor and State Extension Specialist, Entomology</td>
<td>Department of Plant Pathology 1712 Claffin Road 4603 Throckmorton Center Kansas State University Manhattan, KS 66506</td>
</tr>
<tr>
<td>Megan Kennelly</td>
<td>Professor and State Extension Specialist, Plant Pathology</td>
<td>Department of Plant Pathology 1712 Claffin Road 4601 Throckmorton Center Kansas State University Manhattan, KS 66506</td>
</tr>
<tr>
<td>Judy O’Mara</td>
<td>Director, KSU Plant Disease Diagnostic Laboratory</td>
<td>Department of Plant Pathology 1712 Claffin Road 4601 Throckmorton Center Kansas State University Manhattan, KS 66506</td>
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**Michigan**

Michigan State University Extension Vegetables: msue.anr.msu.edu/topic/info/vegetables

Michigan State University Enviro-Weather: enviro-weather.msu.edu

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<tbody>
<tr>
<td>Horticulture</td>
<td>Dan Brainard</td>
<td>(517) 353-0417</td>
<td><a href="mailto:brainar9@msu.edu">brainar9@msu.edu</a></td>
</tr>
<tr>
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<td>Mary Hausbeck</td>
<td>(517) 355-4534</td>
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</tr>
<tr>
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<td>Zachary Hayden</td>
<td>(517) 353-0410</td>
<td><a href="mailto:haydenza@msu.edu">haydenza@msu.edu</a></td>
</tr>
<tr>
<td>Entomology</td>
<td>Zsofia Szendrei</td>
<td>(517) 974-8610</td>
<td><a href="mailto:szendrei@msu.edu">szendrei@msu.edu</a></td>
</tr>
<tr>
<td>Weed Science</td>
<td>Bernie Zandstra</td>
<td>(517) 353-6637</td>
<td><a href="mailto:zandstra@msu.edu">zandstra@msu.edu</a></td>
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<tr>
<td>Southwest Lower Peninsula</td>
<td>Ron Goldy</td>
<td>(269) 944-1477 x 207</td>
<td><a href="mailto:goldy@msu.edu">goldy@msu.edu</a></td>
</tr>
<tr>
<td>Thumb Area Lower Peninsula</td>
<td>Hal Hudson</td>
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</tr>
<tr>
<td>East Central Lower Peninsula</td>
<td>Ben Phillips</td>
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</tr>
<tr>
<td>Southeast Lower Peninsula</td>
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</tr>
<tr>
<td>Central Lower Peninsula</td>
<td>Fred Springborn</td>
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<td><a href="mailto:springb2@msu.edu">springb2@msu.edu</a></td>
</tr>
<tr>
<td>West Central Lower Peninsula</td>
<td>Ben Werling</td>
<td>(231) 873-2129</td>
<td><a href="mailto:werlingb@msu.edu">werlingb@msu.edu</a></td>
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**Minnesota**

University of Minnesota Extension: www.vegedge.umn.edu

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<tr>
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<th>Educator</th>
<th>Email</th>
<th>Phone</th>
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<tbody>
<tr>
<td>Agronomy St. Paul</td>
<td>Roger Becker</td>
<td><a href="mailto:becke003@umn.edu">becke003@umn.edu</a></td>
<td>(612) 625-5753</td>
<td></td>
</tr>
<tr>
<td>Southern Research and Outreach Center Waseca</td>
<td>Vince Fritz</td>
<td><a href="mailto:vafritz@umn.edu">vafritz@umn.edu</a></td>
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<tr>
<td>Vegetable Insects St. Paul</td>
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<td>(612) 624-1767</td>
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<tr>
<td>Vegetable Diseases</td>
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<td>(612) 625-9274</td>
<td></td>
</tr>
<tr>
<td>Soil Science/Horticulture St. Paul</td>
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<td>(612) 625-8114</td>
<td></td>
</tr>
<tr>
<td>Horticulture St. Paul</td>
<td>Cindy Tong</td>
<td><a href="mailto:ctong@tc.umn.edu">ctong@tc.umn.edu</a></td>
<td>(612) 624-3419</td>
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<tr>
<td>Farmington Regional Office</td>
<td>Karl Foord</td>
<td><a href="mailto:foord001@umn.edu">foord001@umn.edu</a></td>
<td>(651) 480-7788</td>
</tr>
<tr>
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<td>Michelle Grabowski</td>
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<td>651-319-2551</td>
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<tr>
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</tr>
<tr>
<td>Plant Diagnostic Laboratory</td>
<td>Brett Arnez</td>
<td>pdc.umn.edu</td>
<td>(612) 625-1275</td>
</tr>
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</table>
Missouri has two Land-grant institutions: University of Missouri (extension.missouri.edu) and Lincoln University of Missouri (www.lincolnu.edu/web/cooperative-extension). This table includes contact information of extension contacts from both universities.

### Statewide Extension Specialists and Faculty

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<thead>
<tr>
<th>Name</th>
<th>Contact Information</th>
<th>Discipline of Service</th>
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<tbody>
<tr>
<td>Touria Eaton, Ph.D. State Extension Specialist</td>
<td>(573) 681-5174 <a href="mailto:EatonT@lincolnu.edu">EatonT@lincolnu.edu</a></td>
<td>Vegetable Production And Soil Fertility</td>
</tr>
<tr>
<td>University of Missouri Commercial Vegetable Program Leader</td>
<td></td>
<td></td>
</tr>
<tr>
<td>David Trinklein, Ph.D. State Extension Specialist</td>
<td>(573) 882-7511 <a href="mailto:TrinkleinD@missouri.edu">TrinkleinD@missouri.edu</a></td>
<td>Greenhouse Crop Production</td>
</tr>
<tr>
<td>University of Missouri</td>
<td></td>
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</tr>
<tr>
<td>Jaime Piñero, Ph.D. State Extension Specialist</td>
<td>(573) 681-5522 <a href="mailto:Pinerof@lincolnu.edu">Pinerof@lincolnu.edu</a></td>
<td>Insect Management</td>
</tr>
<tr>
<td>Integrated Pest Management Program Leader Lincoln University</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zelalem Mersha, Ph.D. State Extension Specialist</td>
<td>(573) 681-5634 <a href="mailto:MershaZ@lincolnu.edu">MershaZ@lincolnu.edu</a></td>
<td>Disease Management</td>
</tr>
<tr>
<td>Integrated Disease Management Program Leader Lincoln University</td>
<td></td>
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<tr>
<td>Patti Hosack State Extension Specialist</td>
<td>(573) 882-3019 <a href="mailto:plantclinic@missouri.edu">plantclinic@missouri.edu</a></td>
<td>Plant Disease Diagnostics</td>
</tr>
<tr>
<td>Plant Diagnostic Clinic University of Missouri</td>
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### Statewide Extension Specialists and Faculty

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<th>Region, Counties, or Cities of Service</th>
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<tbody>
<tr>
<td>Southeast All southeast counties</td>
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<td>(573) 686-8064; <a href="mailto:denklers@missouri.edu">denklers@missouri.edu</a></td>
<td>Vegetable Production</td>
</tr>
<tr>
<td>Bollinger</td>
<td>Donna Aufdenberg Regional Hort. Specialist University of Missouri</td>
<td>(573) 238-2420 <a href="mailto:aufdenbergd@missouri.edu">aufdenbergd@missouri.edu</a></td>
<td>Vegetable Production</td>
</tr>
<tr>
<td>Dunklin, Pemiscot, and New Madrid</td>
<td>Richard Rickman Farm Outreach Worker Lincoln University</td>
<td>(573) 344-9645 <a href="mailto:rickmanR@lincolnu.edu">rickmanR@lincolnu.edu</a></td>
<td>Small Farms Vegetable Production</td>
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<tr>
<td>Butler, Stoddard, and Scott</td>
<td>David Robinson Farm Outreach Worker Lincoln University</td>
<td>(573) 703-6551 <a href="mailto:RobinsonD@lincolnu.edu">RobinsonD@lincolnu.edu</a></td>
<td>Small Farms Vegetable Production</td>
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<tr>
<td>Greene, Christian, Taney, Webster, Wright, Ozark, Douglas, Texas and Howell</td>
<td>Patrick Byers Regional Hort. Specialist University of Missouri</td>
<td>(417) 881-8909 <a href="mailto:byerspl@missouri.edu">byerspl@missouri.edu</a></td>
<td>Vegetable Production</td>
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<td>Jasper, Barry, Barton, Jasper, Dade, Lawrence, McDonald, Newton, and Stone</td>
<td>Robert Balek Regional Hort. Specialist University of Missouri</td>
<td>(417)358-2158 <a href="mailto:balekr@missouri.edu">balekr@missouri.edu</a></td>
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<tr>
<td>Barry and McDonald</td>
<td>Nahshon Bishop Small Farm Specialist Lincoln University</td>
<td>(417) 846-3948; <a href="mailto:BishopN@LincolnU.edu">BishopN@LincolnU.edu</a></td>
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<tr>
<td>Newton and Jasper</td>
<td>Stephen “Randy” Garrett Farm Outreach Worker Lincoln University</td>
<td>(417) 850-9391 <a href="mailto:GarrettS@LincolnU.edu">GarrettS@LincolnU.edu</a></td>
<td>Small Farms Vegetable Production</td>
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<tr>
<td>Lawrence and Greene</td>
<td>David Middleton Farm Outreach Worker Lincoln University</td>
<td>(417) 466-8056 <a href="mailto:MiddletonD@LincolnU.edu">MiddletonD@LincolnU.edu</a></td>
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<td><strong>Northeast</strong></td>
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<tr>
<td>Adair, Clark, Knox, Lewis, Linn, Macon, Putnam, Schuyler, Scotland, Sullivan and Randolph</td>
<td>Jennifer Schutter</td>
<td>(660) 665-9866 <a href="mailto:schutterjl@missouri.edu">schutterjl@missouri.edu</a></td>
<td>Vegetable Production</td>
</tr>
<tr>
<td>Shelby and Northeastern counties</td>
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<td>(573) 633-2640 <a href="mailto:GloverM@missouri.edu">GloverM@missouri.edu</a></td>
<td>Vegetable Production</td>
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<tr>
<td>Dakota and Northeastern counties</td>
<td>Timothy Baker</td>
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<tr>
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<td>Tom Fowler</td>
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<td>Vegetable Production</td>
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<tr>
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<tr>
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<tr>
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<tr>
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<tr>
<td>St. Charles and Lincoln</td>
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<td>Vegetable Production</td>
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<tr>
<td>Platte and Clay counties</td>
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<td>Vegetable Production</td>
</tr>
<tr>
<td>Lafayette and Ray counties</td>
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<td>Vegetable Production</td>
</tr>
<tr>
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<tr>
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<tr>
<td>St. Louis City</td>
<td>Karen Davis</td>
<td>(314) 867-4915 <a href="mailto:davidK@lincolnu.edu">davidK@lincolnu.edu</a></td>
<td>Urban Vegetable Production</td>
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<tr>
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<td>Regional Horticulture Specialist Lincoln University</td>
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<tr>
<td>St. Louis City</td>
<td>Nathan Brandt</td>
<td>(314) 615-7610 <a href="mailto:BrandtN@missouri.edu">BrandtN@missouri.edu</a></td>
<td>Urban Vegetable Production</td>
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<td>Regional Horticulture Specialist University of Missouri</td>
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<tr>
<td>Jefferson</td>
<td>Debi Kelly</td>
<td>(636) 797-5391 <a href="mailto:KellyD@missouri.edu">KellyD@missouri.edu</a></td>
<td>Vegetable Production</td>
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<tr>
<td></td>
<td>Horticulture and Local Foods Specialist University of Missouri</td>
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</tr>
<tr>
<td>Kansas City</td>
<td>Cory Creed</td>
<td>(816) 270-2141 <a href="mailto:creedca@missouri.edu">creedca@missouri.edu</a></td>
<td>Urban Vegetable Production</td>
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<tr>
<td>Kansas City</td>
<td>Lala Kumar</td>
<td>(816) 252-5051 <a href="mailto:KumarL@missouri.edu">KumarL@missouri.edu</a></td>
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<tr>
<td>St. Charles, Warren and Lincoln</td>
<td>Rich Hoormann</td>
<td>(636) 970-3000 <a href="mailto:hoormannr@missouri.edu">hoormannr@missouri.edu</a></td>
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**Ohio**

Ohio State University Extension: extension.osu.edu

### Vegetable Production and Pest Management Specialists

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<thead>
<tr>
<th>Name</th>
<th>Phone</th>
<th>Email</th>
</tr>
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<tbody>
<tr>
<td>Brad Bergefurd</td>
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<tr>
<td>Eric Barrett</td>
<td>(330) 533-5538</td>
<td><a href="mailto:barrett.90@osu.edu">barrett.90@osu.edu</a></td>
</tr>
</tbody>
</table>

**County-based Specialists**

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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. For information or to order, contact Jim Jasinski, Department of Entomology, Ohio State University; (937) 484-1526; or jasinski.4@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.

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 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.

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.
Soil Fertility and Nutrient Management

• **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:

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>CEC Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sands</td>
<td>5-15</td>
</tr>
<tr>
<td>Silts</td>
<td>8-30</td>
</tr>
<tr>
<td>Clays</td>
<td>25-50</td>
</tr>
<tr>
<td>Organic soils</td>
<td>50+</td>
</tr>
</tbody>
</table>

• **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 culls 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 (P2O5 ) and pounds of potash (K2O) 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, P2O5, and K2O 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 P2O5, and 10 percent K2O. So a pound of this fertilizer would contain 0.1 pound each of N, P2O5, and K2O. Urea labeled 46-0-0 contains 46 percent N, 0 percent P2O5, and 0 percent K2O. Potassium chloride (muriate of potash) labeled 0-0-60 contains 0 percent N, 0 percent P2O5, and 60 percent K2O. Organic fertilizers are also labeled this way — a 3-2-2 product contains 3 percent N, 2 percent P2O5, and 2 percent K2O. 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 K2O 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 K2O = 100 pounds of K2O).

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 K2O = 100 pounds of K2O).
But that same fertilizer would also supply 100 pounds of P2O5 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 K2O 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.
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:

\[(\text{RatePerA} \times \text{BS}) \div 43,560 = \text{RatePerLBF}\]
### Table 1: Rate per Linear Bed Foot for Various Bed Spacings and Rates

<table>
<thead>
<tr>
<th>Bed Spacing (ft)</th>
<th>Linear Bed Feet (LBF) in 1 Acre</th>
<th>Fertilizer Rate (lbs./A)</th>
<th>Fertilizer Rate (lb./LBF)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>14,520</td>
<td>0.0014</td>
<td>0.0028</td>
</tr>
<tr>
<td>4</td>
<td>10,890</td>
<td>0.0018</td>
<td>0.0037</td>
</tr>
<tr>
<td>5</td>
<td>8,712</td>
<td>0.0023</td>
<td>0.0046</td>
</tr>
<tr>
<td>6</td>
<td>7,260</td>
<td>0.0028</td>
<td>0.0055</td>
</tr>
<tr>
<td>7</td>
<td>6,222</td>
<td>0.0032</td>
<td>0.0064</td>
</tr>
<tr>
<td>8</td>
<td>5,445</td>
<td>0.0037</td>
<td>0.0073</td>
</tr>
<tr>
<td>9</td>
<td>4,840</td>
<td>0.0041</td>
<td>0.0083</td>
</tr>
<tr>
<td>10</td>
<td>4,356</td>
<td>0.0046</td>
<td>0.0092</td>
</tr>
</tbody>
</table>

Example:

Bed spacing (BS) = 5 ft. between centers of beds.
Fertilizer rate in lb./A (Rate per A) = 100 lbs./A

\[
\frac{(100 \times 5)}{43,560} = 0.0115 \text{ lb. per LBF}
\]

For a crop on six 100-foot beds, there would be 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.

Table 1 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 (NH$_4^+$) or nitrate (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...
Soil Fertility and Nutrient Management

Ammonium in the soil solution exists in equilibrium with ammonia gas (NH₃). 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.

Volatile 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 (SO₄²⁻). 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 (CaSO$_4$·2H$_2$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 fitting. 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.


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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.

Table 2 (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.

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 4
June-September: Cucumber production
September-November: Oats and field peas as a cover crop

Year 5
Return to Year 1
Soil Fertility and Nutrient Management

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
Table 2: Green Manure Crops for Vegetable Farms

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

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.

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.

**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 over watering 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 pelleting. 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 pelleted 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 over watering. 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 transplanter 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 (Table 3). Once introduced, these pathogens may continue to cause problems year after year if proper precautions are not taken.

### Table 3: Common Seedborne Diseases of Vegetable Crops Frequently Grown as Transplants

<table>
<thead>
<tr>
<th>Vegetable Crop</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>cabbage</td>
<td>black rot, Alternaria leaf spot</td>
</tr>
<tr>
<td>cantaloupe</td>
<td>anthracnose, gummy stem blight</td>
</tr>
<tr>
<td>cucumber</td>
<td>angular leaf spot</td>
</tr>
<tr>
<td>pepper</td>
<td>bacterial spot</td>
</tr>
<tr>
<td>squash</td>
<td>squash mosaic (squash mosaic virus)</td>
</tr>
<tr>
<td>tomato</td>
<td>bacterial canker, bacterial speck, bacterial spot</td>
</tr>
<tr>
<td>watermelon</td>
<td>anthracnose, gummy stem blight, bacterial fruit blotch</td>
</tr>
</tbody>
</table>

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 Table 14 for liquid pesticide conversion table).
- 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.


A few chemicals are labeled for disease control in greenhouse vegetable crops. Restricted use pesticides can only be used by certified pesticide app licators 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 tables 16 and 17 on page 45.

### 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, ohiol ine.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 Table 4 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.

**Table 4: Water Bath Temperatures and Treatment Lengths**

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

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

**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, ohioline.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.

#### Table 5: Effective Rooting Depth of Selected Vegetables

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

#### Table 6: Vegetable Crops and Growth Period Most Critical for Irrigation Requirements

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

1For 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. Table 7 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.

Table 7: Available Water Holding Capacities for Several Soil Types

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

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 Table 8 (below) to estimate the inches of soil water deficit for a given tension reading; use Table 9 (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 (Table 8). 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 (Table 9).

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.

Table 8: Soil Water Deficit Estimates for Different Soil Textures and Selected Tensions

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

1,500 cbs refers to the permanent wilting point and the soil deficit value is equal to the soil’s total available water capacity.
Table 9: Soil Tension Values for Different Soil Textures For Use in Scheduling Trickle Irrigation

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>0% Depletion of Available Water Holding Capacity (Field Capacity)¹</th>
<th>20-25% Depletion of Available Water Holding Capacity²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand, loamy sand</td>
<td>5-10</td>
<td>17-22</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>10-20</td>
<td>22-27</td>
</tr>
<tr>
<td>Loam, silt loam</td>
<td>15-25</td>
<td>25-30</td>
</tr>
<tr>
<td>Clay loam, clay</td>
<td>20-40</td>
<td>35-45</td>
</tr>
</tbody>
</table>

¹At field capacity the soil contains 100 percent of AWHC; any excess water in the rootzone has drained away.
²Start 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, Calif., 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.

Honeybees 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. Honeybees 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 honeybees.

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

In addition to renting honeybee 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) and Pollinator Partnership (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 honeybee 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:

- **cantaloupe**: (2 to 3 colonies per acre)
- **cucumber**: (2 to 3 colonies per acre)
- **pumpkin**: (1 colony per acre)
- **squash**: (1 colony per acre)
- **watermelon**: (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**

Honeybees 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**

Certain pesticides and pesticide application methods may pose a hazard to honey bees, bumble bees, and native bees. Generally, early morning or late evening pesticide applications are less hazardous to bees, because bees are generally less active.

Do not apply pesticides to flowering plants or weeds. Applying a single pesticide product may be less hazardous to bees than mixtures or combinations. That's because potential synergistic effects can increase the toxicity of certain pesticides to bees. Systemic insecticides (applied as either granules or drenches to the soil or growing medium) are less toxic to bees than foliar applications. Emulsifiable concentrate or water-soluble formulations are typically less hazardous to bees than wettable powder formulations.

Table 10 (page 32) classifies pesticides (insecticides and miticides) based on their toxicity to honey bees. It is important to read pesticide labels carefully to determine their level of toxicity to honey bees. In addition, you can incorporate into pollination contracts a list of pesticides, application methods, and timing of applications that are mutually agreeable to both growers and beekeepers.

Ohio law requires that applicators notify beekeepers 24 hours before applying a pesticide that is toxic to honey bees when (1) the treated crop is blooming, and (2) the field is greater than a half-acre and within half-a-mile from a registered apiary. Contact your state department of agriculture to determine if similar laws exist to protect other pollinators.

Make sure to work with beekeepers to avoid applying pesticides that could harm the bees.
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®) 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.

Table 10: Toxicity of Insecticides to Bees

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®) 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.

<table>
<thead>
<tr>
<th>Very High Toxicity</th>
<th>High Toxicity</th>
<th>Moderate Toxicity</th>
<th>Low Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Actara&quot; (thiamethoxam)</td>
<td>Agri-Mek® (abamectin)</td>
<td>*Acramite® (bifenthrin)</td>
<td>*Beleaf® (flonicamid)</td>
</tr>
<tr>
<td>Agri-Mek® (abamectin), &gt;21 fl oz/A</td>
<td>Asana® (esfenvalerate), 4.8 fl oz/A</td>
<td>Ammo® (cypermethrin), &lt;1.28 fl oz/A</td>
<td>Cryolite® (cryolite)</td>
</tr>
<tr>
<td>Ambush® (permethrin)</td>
<td>Brigade® (bifenthrin), 2.56 fl oz/A</td>
<td>*Assail® (acetamiprid)</td>
<td>*Dimilin® (diflubenzuron)</td>
</tr>
<tr>
<td>Amino® (cypermethrin), &gt;1.28 fl oz/A</td>
<td>Confirm® (tebufluzate) &lt;21 fl oz/A</td>
<td>*Avaunt® (indoxacarb)</td>
<td>DiPel® (Bacillus thuringiensis)</td>
</tr>
<tr>
<td>Asana® (esfenvalerate), 7.3 fl oz/A</td>
<td>Dibrom EC® (naled)</td>
<td>Azatin® (neem)</td>
<td>Diazinon G® (diazinon)</td>
</tr>
<tr>
<td>Baythroid® (cyfluthrin)</td>
<td>Di-Syston 8EC®, 16 fl oz/A</td>
<td>Brigade® (bifenthrin), &lt;2.56 fl oz/A</td>
<td>Di-Syston G® (disulfoton)</td>
</tr>
<tr>
<td>Brigade® (bifenthrin), &gt;23.8 fl oz/A</td>
<td>Malathion EC® (malathion)</td>
<td>*Decis® (deltamethrin)</td>
<td>*Esteem® (pyriproxyfen)</td>
</tr>
<tr>
<td>Danitol® (fenpropatrin)</td>
<td>*Proaxis® (gamma-cyhalothrin), 2.56 fl oz/A</td>
<td>Diacept® (diatomaceous earth)</td>
<td>Garlic Barrier®</td>
</tr>
<tr>
<td>Diazinon® (diazinon)</td>
<td>Sevin XLR PLUS®, &lt;48 fl oz/A</td>
<td>Di-Syston EC® (disulfoton), 8 fl oz/A</td>
<td>Hot Pepper Wax® (capsaicin)</td>
</tr>
<tr>
<td>Dibrom® WP or D (naled)</td>
<td>Thimet EC® (phorate)</td>
<td>Fulfill® (pymetrozine)</td>
<td>*Intrepid® (methoxyfenozide)</td>
</tr>
<tr>
<td>Dimethoate® (dimethoate)</td>
<td>Vdate® (oxamyl), &gt;64 fl oz/A</td>
<td>Lannate® (methomyl)</td>
<td>Kryocide® (cryolite)</td>
</tr>
<tr>
<td>Imidan® (phosmet)</td>
<td>Warrior® (lambda-cyhalothrin), 2.56 fl oz/A</td>
<td>Malathion ULV® (malathion), &lt;3 fl oz/A</td>
<td>Malathion G® (malathion)</td>
</tr>
<tr>
<td>Lorsban® (chlorpyrifos)</td>
<td></td>
<td>Metasystox-R® (oxydemeton methyl)</td>
<td>Metaldehyde® Bait (metaldehyde)</td>
</tr>
<tr>
<td>Malathion WP® (malathion)</td>
<td></td>
<td>Neemix® (neem)</td>
<td>Mocap G® (ethoprop)</td>
</tr>
<tr>
<td>Malathion ULV® (malathion), &gt;8 fl oz/A</td>
<td>Proclaim® (emamectin benzoate)</td>
<td>M-Pede® (soap)</td>
<td></td>
</tr>
<tr>
<td>Mustang Maxx® (zeta-cypermethrin)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthene® (acephate)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pounce® (permethrin)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Proaxis® (gamma-cyhalothrin), 3.84 fl oz/A</td>
<td></td>
<td></td>
<td>*Surround® (kaolin)</td>
</tr>
<tr>
<td>Sevin 50WP® (carbaryl)</td>
<td></td>
<td></td>
<td>Vendex® (fenbutatin-oxide)</td>
</tr>
<tr>
<td>Sevin XLR-Plus®, &gt;48 fl oz/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warrior® (lambda-cyhalothrin), 3.84 fl oz/A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


1Do not apply these to blooming crops or weeds at any time of day or night.
2Apply only during late evening (6 pm to midnight).
3Apply only during late evening, night or early morning (6 pm to 7 am).
4Can be applied at any time with reasonable safety to bees.
5Products marked are relatively new and do not appear in the source cited, but information on their toxicity was taken from various Extension sources.
**Table 11: Approximate Time from Pollination to Market Maturity Under Warm Growing Conditions**

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

\(^1\)From 50% silking.

\(^2\)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 possible 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.
Rules for Pesticides with ‘Danger’ Signal Word

Formulations of Monitor®, Lannate®, Thimet®, DiSyston®, Guthion®, and Gramoxone® are highly poisonous. They should not be applied unless applicators strictly follow all precautions listed on pesticide labels.

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.

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

Ground Equipment

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).

Boom Sprayer Calibration

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

1. Clean the sprayer and replace all worn parts.
2. Fill the tank with water.
3. Adjust sprayer pressure and tractor speed for nozzle size and output by following manufacturer's directions.
4. Spray 1/8 of an acre (5,445 square feet) — the actual distance you travel will vary with boom width. For example, a 22-foot boom must travel 248 feet to cover 5,445 square feet.

\[
\frac{1/8 \text{ A (5,445 square feet)}}{\text{Boom width (22 feet)}} = \frac{\text{Distance}}{(248 \text{ feet})}
\]

5. After spraying, measure the amount of water you need to refill the tank. This is the amount you applied to the test area of 1/8 acre; thus, you need 8 times that amount to spray an acre.
6. Adjust spray output by varying the tractor speed or changing the nozzle sizes or pressure. Recalibrate after making any adjustments.
7. Calculate the acres covered by the tank of spray solution and add the required amount of pesticide for the total area to be 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.

**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.

**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.

Reduced-risk /Biopesticides

Every pesticide has a different impact on human health and the environment. Until recently, it has been impossible for growers to know the impact of the pesticides they apply. Now, however, the U.S. Environmental Protection Agency (EPA) lists biopesticides and pesticides that have reduced risks in specific areas.

Pesticides classified as reduced-risk by the EPA are conventional products that have:

- Low impact on human health.
- Low toxicity to nontarget organisms (birds, fish, and plants).
- Low potential for groundwater contamination.
- Lower use rates.
- Low pest resistance potential.
- Compatibility with Integrated Pest Management.

The EPA bases reduced-risk decisions on specific uses of pesticide combinations. Thus, a pesticide may be considered reduced risk for one vegetable, but not another.

Biopesticides are derived from natural materials such as animals, plants, bacteria, and certain minerals. Biopesticides fall into three major classes: microbial pesticides, plant-incorporated protectants, and biochemical pesticides. The active ingredient in a microbial pesticide (or mycoinsecticide) is a microorganism (bacterium, fungus, virus, or protozoa). These are highly selective in activity against specific target insect pests. Plant-incorporated protectants are substances that plants produce based on genetic material that is incorporated into plants. Biochemical pesticides are naturally occurring substances that control insect pests through nontoxic mechanisms such as sex pheromones or scented plant extracts.

The EPA defines biopesticides as products that include: “naturally occurring substances that control pests (biochemical pesticides), microorganisms that control pests (microbial pesticides), and pesticidal substances produced by plants containing added genetic material (plant-incorporated protectants) or PIPs.”

In this guide, products that are defined as reduced risk for a given vegetable or vegetable group are denoted by the symbol ▲. Biopesticides are denoted by the symbol ▲. ▲

As with any product, investigate these or any new products before you need them. If a product is not commonly used in your area, it may not be locally or quickly available.

## Pesticide Application Record and Written Notification for EPA Worker Protection Standards

<table>
<thead>
<tr>
<th>Business Name</th>
<th>Location</th>
<th>Pesticide</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Field</td>
<td>Crop</td>
<td></td>
</tr>
</tbody>
</table>

- **Product Brand Name & Chemical Formulation**
- **Active Ingredient**
- **Name of Manufacturer**
- **EPA Registration Number**
- **Pesticide Rate**
- **Total Amount of Pesticides Used**
- **Name & Certification No. of Applicator or Certified Supervisor**
- **Date (Mo./Day/Year)**
- **Time**
- **Restricted Entry Interval (hrs.)**
- **OK to Enter (Date & Time)**

---

1 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.

2 For EPA Worker Protection Standard, information in shaded columns must be recorded for all pesticides and be maintained at the centrally located posting area for 30 days after the restricted entry interval expires.

3 Formulation required if included in product name: DF=flowable, EC & E=emulsifiable concentrate, G=granules, F=flowable, L=liquid, S=soluble, ULV=ultra low volume, etc.

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.

In this guide, products that may be allowed in organic production are denoted by the symbol: ☑. 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.

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).

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).

Appropriate Technology for Rural Areas (ATTRA) offers a number of publications on their website: 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.

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.

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/publicationsaboutpestmanagement.

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 2016. Contact them directly for information about fees and the certification procedure. Additional accredited organizations are listed at www.ams.usda.gov/services/organic-certification/certifying-agents.

Consult your local extension office for other resources available in your area.
Selected Organic Certification Agents

California Certified Organic Farmers
Serves entire United States, Canada, and Mexico
2155 Delaware Avenue, Suite 150
Santa Cruz, CA 95060
(831) 423-2263
Fax: (831) 423-4528
ccof@ccof.org
www.ccof.org

Ecocert ICO
Serves entire United States
201 W. Main St., 2nd Floor
Plainfield, IN 46168
(888) 337-8246
info.ecocertico@ecocert.com
www.ecocertico.com

Global Organic Alliance
Services entire United States, Canada, Mexico, Russia, and select countries in Central America, South America, and Asia
P.O. Box 530
3185 Township Road 179
Bellefontaine, OH 43311
(937) 593-1232
Fax: (937) 593-9507
goaorg@centurylink.net
www.goa-online.org

International Certification Services
Services worldwide
301 5th Avenue SE
Medina, ND 58467
(701) 486-3578
Fax: (701) 486-3580
info@ics-intl.com
www.ics-intl.com

Iowa Department of Agriculture and Land Stewardship
Services Iowa and neighboring states
Organic Certification Program
Maury Wills
502 East 9th Street
Des Moines, IA 50319
(515) 281-5783
AgDiversification@iowaagriculture.gov
www.iowaagriculture.gov/AgDiversification/organicCertification.asp

Midwest Organic Services Association, Inc.
Services 20 states
122 W. Jefferson St.
PO Box 821
Viroqua, WI 54665
(608) 637-2526
mosa@mosaorganic.org
www.mosaorganic.org

Minnesota Crop Improvement Association
Services the Midwest and beyond
1900 Hendon Ave.
St. Paul, MN 55108
(612) 625-7766
(800) 510-MCIA
mncia@mncia.org
www.mncia.org

Nature's International Certification Services
Services 18 states, including Illinois, Iowa, Michigan, Minnesota, Missouri, and Ohio
224 State Highway 56 East
Viroqua, WI 54665
(608) 637-7080
Fax: (608) 637-7460
nics@naturesinternational.com
www.naturesinternational.com

OCIA International, Inc.
Services the Americas and Asia
1340 North Cotner Blvd.
Lincoln, NE 68505
Phone: (402) 477-2323
info@ocia.org
www.ocia.org

Oregon Tilth Certified Organic
Services entire United States, Canada, and Mexico
2525 SE 3rd St.
Corvallis, OR 97333
(503) 378-0690
(877) 378-0690
Fax: (541) 753-4924
organic@tilth.org
www.tilth.org
Ohio Ecological Food and Farm Association
Services 10 states, including Illinois, Indiana, Iowa, Michigan, Missouri, and Ohio
41 Croswell Road
Columbus, OH 43214
(614) 262-2022
organic@oeffa.org
www.oeffa.org

OneCert, Inc.
Services most of the United States
2219 C Street
Lincoln, NE 68502
(402) 420-6080
info@onecert.com
www.onecert.com

Pro-Cert Organic
Services entire United States and Canada
P.O. Box 74
2311 Elm Tree Road
Cambray, ON K0M 1E0 Canada
(705) 374-5602
Fax: (705) 374-5604
infoeb@pro-cert.org
www.pro-cert.org

Quality Assurance International
Services entire United States and Canada
9191 Towne Centre Drive, Suite 200
San Diego, CA 92122
(858) 200-9704
info@qai-inc.com
www.qai-inc.com

Quality Certification Services
Services most of the United States
PO Box 12311
Gainesville, FL 32604-0311
(352) 377-0133
Fax: (352) 377-8363
qcs@qcsinfo.org
www.qcsinfo.org

Table 12: Yields of Vegetable Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Expected Yields in Tons per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>Asparagus</td>
<td>1</td>
</tr>
<tr>
<td>Bean, snap</td>
<td>2</td>
</tr>
<tr>
<td>Cabbage</td>
<td>13</td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>10</td>
</tr>
<tr>
<td>Cucumber (slicing)</td>
<td>9</td>
</tr>
<tr>
<td>Cucumber (pickling, hand harvest)</td>
<td>6</td>
</tr>
<tr>
<td>Onion</td>
<td>13</td>
</tr>
<tr>
<td>Pepper, green</td>
<td>14</td>
</tr>
<tr>
<td>Potato (fall)</td>
<td>10</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>10</td>
</tr>
<tr>
<td>Spinach</td>
<td>6</td>
</tr>
<tr>
<td>Summer squash</td>
<td>10</td>
</tr>
<tr>
<td>Sweet corn</td>
<td>4.5</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>7</td>
</tr>
<tr>
<td>Tomato (fresh market)</td>
<td>11</td>
</tr>
<tr>
<td>Tomato (processing)</td>
<td>25</td>
</tr>
<tr>
<td>Watermelon</td>
<td>15</td>
</tr>
</tbody>
</table>

This table only provides general yield estimates for new or prospective growers. The USDA-National Agricultural Statistics Service Vegetable Survey provides more accurate information.
Table 13: 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.


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

*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.

bFall-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.

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.

Table 14: Conversions for Liquid Pesticides on Small Areas

<table>
<thead>
<tr>
<th>Rate per Acre</th>
<th>Rate per 1,000 Square Feet</th>
<th>Rate per 100 Square Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 pint</td>
<td>0.75 tablespoon</td>
<td>0.25 teaspoon</td>
</tr>
<tr>
<td>1 quart</td>
<td>1.5 tablespoons</td>
<td>0.5 teaspoon</td>
</tr>
<tr>
<td>2 quarts</td>
<td>3 tablespoons</td>
<td>1 teaspoon</td>
</tr>
<tr>
<td>1 gallon</td>
<td>6 tablespoons</td>
<td>2 teaspoons</td>
</tr>
<tr>
<td>25 gallons</td>
<td>4.5 pints</td>
<td>1 cup</td>
</tr>
<tr>
<td>50 gallons</td>
<td>4.5 quarts</td>
<td>1 pint</td>
</tr>
<tr>
<td>75 gallons</td>
<td>7 quarts</td>
<td>1.5 pints</td>
</tr>
<tr>
<td>100 gallons</td>
<td>9 quarts</td>
<td>1 quart</td>
</tr>
</tbody>
</table>

Check the pesticide label for the particular crop, pest, and site of your planned use.
## Table 15: Germination and Growing Guide for Vegetable Plants and Herbs

<table>
<thead>
<tr>
<th>Crop</th>
<th>No. of Seeds per Oz</th>
<th>Opt. Germination Temp. (°F)</th>
<th>Usual Day Temp. (°F)</th>
<th>Min. Night Temp. (°F)</th>
<th>Time for Uniform Germination (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asparagus</td>
<td>700</td>
<td>75</td>
<td></td>
<td></td>
<td>10-21</td>
</tr>
<tr>
<td>Broccoli</td>
<td>9,000</td>
<td>68-86</td>
<td>65-70</td>
<td>60</td>
<td>5-10</td>
</tr>
<tr>
<td>Brussels sprouts</td>
<td>9,000</td>
<td>68-86</td>
<td></td>
<td></td>
<td>5-10</td>
</tr>
<tr>
<td>Cabbage</td>
<td>9,000</td>
<td>85</td>
<td>65</td>
<td>60</td>
<td>5-10</td>
</tr>
<tr>
<td>Chinese cabbage</td>
<td>18,000</td>
<td>85</td>
<td></td>
<td></td>
<td>3-7</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>9,000</td>
<td>80</td>
<td>65-70</td>
<td>60</td>
<td>5-10</td>
</tr>
<tr>
<td>Celery</td>
<td>72,000</td>
<td>70</td>
<td>65-70</td>
<td>60</td>
<td>10-21</td>
</tr>
<tr>
<td>Collards</td>
<td>9,000</td>
<td>68-86</td>
<td></td>
<td></td>
<td>3-10</td>
</tr>
<tr>
<td>Cucumber</td>
<td>1,100</td>
<td>68-86</td>
<td>70-75</td>
<td>65</td>
<td>3-7</td>
</tr>
<tr>
<td>Dandelion (for greens)</td>
<td>35,000</td>
<td>68-86</td>
<td></td>
<td></td>
<td>7-21</td>
</tr>
<tr>
<td>Eggplant</td>
<td>6,500</td>
<td>85</td>
<td>70-85</td>
<td>65</td>
<td>7-14</td>
</tr>
<tr>
<td>Endive</td>
<td>27,000</td>
<td>68-86</td>
<td>70-75</td>
<td>70</td>
<td>5-14</td>
</tr>
<tr>
<td>Kale</td>
<td>9,000</td>
<td>68-86</td>
<td></td>
<td></td>
<td>3-10</td>
</tr>
<tr>
<td>Leek</td>
<td>11,000</td>
<td>68</td>
<td></td>
<td></td>
<td>6-14</td>
</tr>
<tr>
<td>Lettuce</td>
<td>25,000</td>
<td>75</td>
<td>60-65</td>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>Okra</td>
<td>500</td>
<td>68-86</td>
<td></td>
<td></td>
<td>5-14</td>
</tr>
<tr>
<td>Pak-choi</td>
<td>18,000</td>
<td>68-86</td>
<td></td>
<td></td>
<td>3-7</td>
</tr>
<tr>
<td>Parsley</td>
<td>18,500</td>
<td>75</td>
<td></td>
<td></td>
<td>11-28</td>
</tr>
<tr>
<td>Pepper</td>
<td>4,500</td>
<td>85</td>
<td>70-75</td>
<td>60</td>
<td>6-14</td>
</tr>
<tr>
<td>Sweet potato plants</td>
<td></td>
<td></td>
<td>77</td>
<td>75-85</td>
<td>14-21</td>
</tr>
<tr>
<td>(from tuberous roots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bedded in sand)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squash</td>
<td>400</td>
<td>80-90</td>
<td>70-75</td>
<td>65</td>
<td>4-7</td>
</tr>
<tr>
<td>Tomato</td>
<td>11,500</td>
<td>85</td>
<td>65-75</td>
<td>60</td>
<td>5-14</td>
</tr>
</tbody>
</table>

### Herbs

<table>
<thead>
<tr>
<th>Herb</th>
<th>No. of Seeds per Oz</th>
<th>Opt. Germination Temp. (°F)</th>
<th>Usual Day Temp. (°F)</th>
<th>Min. Night Temp. (°F)</th>
<th>Time for Uniform Germination (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anise</td>
<td>9,600</td>
<td>70</td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Basil, dark opal</td>
<td>20,000</td>
<td>70</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Basil, leaves</td>
<td>9,600</td>
<td>70</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Borage</td>
<td>2,100</td>
<td>70</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Chives</td>
<td>22,000</td>
<td>60</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Coriander</td>
<td>1,240</td>
<td>70</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Dill</td>
<td>6,300</td>
<td>60</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Fennel, sweet</td>
<td>4,000</td>
<td>65</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Marjoram, sweet</td>
<td>100,000</td>
<td>70</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Rosemary</td>
<td>30,000</td>
<td>60</td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Sage</td>
<td>3,250</td>
<td>70</td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Thyme</td>
<td>96,000</td>
<td>75</td>
<td></td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>
Pesticide Use in Greenhouses and High Tunnels

Vegetable production in greenhouses and high tunnels has increased throughout the Midwest. Although insects and mites you find in greenhouses may differ from those you find in the field, using pesticides will be necessary to suppress pest populations and prevent plant damage. However, it is important to use pesticides properly in order to maximize performance.

There are three key factors associated with maximizing pesticide performance in greenhouses or high tunnels:

1. Timing
2. Coverage
3. Frequency

1. Timing
It is important to apply insecticides and miticides at the most susceptible life stage of the target insect or mite pest. Generally, the most susceptible life stages for many contact pesticides are the larva, nymph, and adult. The egg and pupa tend to be more resilient, and so less susceptible to pesticides. For this reason, effectively controlling an insect or mite pest means you must understand the pest’s biology.

When applying systemic insecticides to the soil or growing medium, always apply them before you notice phloem-feeding insects (such as aphids and whiteflies). That’s because the systemic insecticide’s active ingredient may take time to move or translocate throughout plants. That movement depends on water solubility (the higher the water solubility, the faster the active ingredient will translocate through the plant vascular system).

Take note that temperature influences a pest’s life cycle (and thus the presence of its susceptible life stages). The higher the temperature, the faster insects and mites develop. So before you apply, consider the effect temperature has had on insect and mite development.

You also want to minimize harm to honey bees. Apply pesticides in the early morning before honey bees are active, or apply them on cloudy, overcast days when honey bees are less active.

2. Coverage
Coverage is particularly important when using contact pesticides. Always try to obtain thorough coverage of all plant parts — including the leaves, stems, and flowers. This way, wet sprays will come in contact with insect and mite pests.

To enhance coverage, you may need to use an adjuvant to improve its spreading ability. Adjuvants are added to pesticide mixtures or solutions to improve or alter deposition, toxicity, mixing ability, persistence, and other attributes that will enhance performance. One type of adjuvant is a surfactant, which reduces the surface tension of spray droplets. This allows the spray to better cover waxy or hairy leaf surfaces of certain plants or the outer coverings (cuticles) of insects and mites. Remember, a number of vegetable crops have waxy leaf surfaces.

3. Frequency
How often you spray will depend on the pesticide’s residual activity. Always read pesticide labels to learn how often it should be applied. In general, recommendations usually call to apply pesticides once every seven days. However, the actual application frequency depends on a pesticide’s residual activity (short-term vs. long-term).

Be aware that too many applications may injure certain vegetable crops. For example, phytotoxicity may occur if you apply insecticidal soaps (potassium salts of fatty acids) or horticultural oils (mineral, petroleum, or neem-based) too frequently (three times per week). Furthermore, applying the same pesticide continuously may promote resistance in the pest populations, so always rotate pesticides with different modes of action.

The time of year or season (spring vs. summer) also may affect the frequency of applications. Again, that’s because of temperature’s influence on the life cycle of the insect or mite pest. As the ambient air temperature increases, it takes less time to complete the life cycle (egg to adult). So high temperatures may require more frequent applications.

State pesticide regulatory agencies in the Midwest have different interpretations of whether a high tunnel is considered a type of greenhouse. For example, Indiana considers a high tunnel to be a type of greenhouse, which means that pesticides labeled for use in a high tunnel may be appropriate for a greenhouse. Other states may consider high tunnels to be the same as fields in terms of pesticide use. And state’s like Missouri have a variable definition. A high tunnel is considered a greenhouse when the sides are closed, but is classified as a field when the sides are open.

In short, be sure how your state classifies high tunnels. For greenhouse pesticide applications, there are three label interpretations, which are presented in Table 16. The first interpretation is that the pesticide label clearly states that the product can be used in greenhouses and must be used according to label directions.
The second interpretation is that the pesticide labels clearly prohibits greenhouse use. Therefore, you should never use these pesticides in a greenhouse.

The third interpretation is that many pesticide labels do not specify whether they can be used in greenhouses. When labels do not prohibit greenhouse use, most state regulatory agencies allow the pesticide can be used in a greenhouse as long as the treated crop is on the label and the pesticide is applied according to label directions.

### Table 16: Insecticide Labeling for Greenhouse Use

<table>
<thead>
<tr>
<th>Labeled for Greenhouse Use</th>
<th>Label Prohibits Greenhouse Use</th>
<th>Label Does Not State Greenhouse Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admire PRO®</td>
<td>Actara®</td>
<td>Acramide®</td>
</tr>
<tr>
<td>Agree® (and other Bacillus thuringiensis products)</td>
<td>Coragen®</td>
<td>Agri-Mek®</td>
</tr>
<tr>
<td>Avaunt®</td>
<td>Di-Syston®</td>
<td>Ambush/Pounce®/ Permethrin®</td>
</tr>
<tr>
<td>Dibrom®</td>
<td>Diazinon®</td>
<td>Ammo®</td>
</tr>
<tr>
<td>DiPel®</td>
<td>Dimethoate®</td>
<td>Asana®</td>
</tr>
<tr>
<td>Entrust®</td>
<td>Movento®</td>
<td>Assail®</td>
</tr>
<tr>
<td>Exirel®</td>
<td>Orthene®</td>
<td>Baythroid®</td>
</tr>
<tr>
<td>Intrepid®</td>
<td>Platinum®</td>
<td>Belay®</td>
</tr>
<tr>
<td>Lannate®</td>
<td>Proclaim®</td>
<td>Beleaf®</td>
</tr>
<tr>
<td>Monitor®</td>
<td>Radiant®</td>
<td>Brigade®</td>
</tr>
<tr>
<td>M-Pede®</td>
<td>Trigard®</td>
<td>Closer®</td>
</tr>
<tr>
<td>Neemix®</td>
<td>Voliam Flexi®</td>
<td>Cryolite®</td>
</tr>
<tr>
<td>Sevin®</td>
<td>Voliam Xpress®</td>
<td>Danitol®</td>
</tr>
<tr>
<td>Vydate®</td>
<td>Voliam Flexi®</td>
<td>Fulfill®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hero®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knack®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kryocide®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Larvin®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leverage®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lorsban®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Malathion®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mustang Maxx®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oberon®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Penncap-M®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rimon®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sivanto®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sulfur</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Venom®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Warrior®</td>
</tr>
</tbody>
</table>

1For example, a tomato grower in the field can use any of the 19 products listed in the entries on pages 135-136 to treat early blight of tomato. In a greenhouse, the same grower could not use Cabrio® and any product with chlorothalonil (such as Endura®, Quadris®, or Zing®). These other product labels prohibit greenhouse use. In the greenhouse, the grower may use other products because the label either specified that it could be used (mancozeb products such as Dithane® or Scala®), or the label did not mention use in the greenhouses (mancozeb products such as Manzate®/Penncozeb®, or Gavel®).  
2For use on basil and tomato transplants only.  
3Additional restrictions for greenhouse use.  
4For use on tomato only.  
5See comment in Leafy Vegetables section.
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) lists diagnostic laboratories by state and region. Contact individual laboratories for specific submission and fee information (see page 46-48).

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 arrive on weekdays.

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. 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 newspaper and cardboard and wrap fruits or tubers in dry newspaper. Place in a crush-proof container for shipment.

Submitted 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. 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
www.facebook.com/UofIPlantClinic

Contact:
Suzanne Bissonnette
sbissonn@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

Contacts:
Tom Creswell
creswell@purdue.edu
Gail Ruhl
ruhlg@purdue.edu

Nematology Laboratory
Department of Entomology
Purdue University
901 W. State Street
West Lafayette, IN 47907-2089
extension.entm.purdue.edu/nematology/services.html

Contact:
Jamal Faghihi
765) 494-5901
jamal@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

Purdue Agronomy Extension lists labs that participate in proficiency testing programs for soil, plant tissue, and manure testing at ag.purdue.edu/agry/extension/Pages/soil_testing.aspx

Iowa

Iowa State University Plant and Insect Diagnostic Clinic
327 Bessey Hall
Iowa State University
Ames, IA 50011
(515) 294-0581
Fax: (515) 294-9420
www.ent.iastate.edu/pidc

Contact:
Laura Jesse
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

The Iowa Department of Agriculture and Land Stewardship lists private certified soil testing laboratories at www.iowaagriculture.gov/feedAndFertilizer/pdfs/2015/CertLabsafterQ42015.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

Kansas

Plant Disease Diagnostic Lab
Extension Plant Pathology
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

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

Contact for general questions:
(517) 432-0988
pestid@msu.edu

MSU Soil and Plant Nutrient Laboratory
Department of Plant, Soil and Microbial Sciences
Plant and Soil Sciences Building
Using a Plant Diagnostic Lab

1066 Bogue Street, Room A81
East Lansing, Michigan 48824-1325
(517) 355-0218
www.spnl.msu.edu
Contact:
Jon Dahl
dahl@msu.edu

**Minnesota**

Plant Disease Clinic
Department of Plant Pathology
495 Borlaug Hall
1991 Upper Buford Circle
University of Minnesota
St. Paul, MN 55108
(612) 625-1275
Fax: (612) 625-9728

pdc.umn.edu
Contact:
Brett Arnaz
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

**Missouri**

Plant Diagnostic Clinic
28 Mumford Hall
Columbia, MO 65211
(573) 882-3019
plantclinic.missouri.edu
Contact:
Patti Hosak
(573) 882-3019
plantclinic@missouri.edu

Plant Nematology Lab
23 Mumford Hall
University of Missouri
Columbia, MO 65211
(573) 884-9118
Fax: (573) 884-4288
soilplantlab.missouri.edu
Contact:
Amanda Howland
nematodelab@missouri.edu

Approved laboratories for soil testing:
Custom Laboratory Inc.
204 C St.
Golden City, MO 64748
(417) 537-8337

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

Perry Agricultural Lab
PO Box 418
State Highway 54 East
Bowling Green, MO 63334
(573) 324-2931

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

Kinsey Agricultural Services, Inc.
297 County Highway 357
Charleston, Missouri 63834
(573) 683-3880

**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
Contact:
Nancy Taylor
taylor.8@osu.edu or ppdc@cfaes.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

**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  
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  
Attn: Jenny Tavares, Monitor Advocate  
Kansas Department of Commerce  
1000 SW Jackson St., STE 100  
(785) 296-5014  
jtavares@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  
2120 Fyffe Road  
Columbus, OH 43210  
(614) 247-7898
On-farm Food Safety

Good Agricultural Practices (GAP) present a set of guidelines that can prevent or reduce the risk of potential contamination of vegetables in the field and during post-harvest production. Foodborne pathogens associated with fresh produce include *E. coli* O157:H7, *Salmonella* spp., *Shigella* spp., Norovirus, hepatitis A virus, *Cyclospora cayatanensis*, and *Listeria monocytogenes*. To reduce the risk of foodborne illness, vegetable growers should adopt GAPs, paying particular attention to water management.

Water Management

Water is essential for crops, but it also is an excellent growth medium for microorganisms. Water is a major source of contamination in crop production. Growers use water for irrigation, washing products, hydro-cooling, icing, applying fertilizers and pesticides, preparing soil amendments, and washing equipment and facilities. It is important to make sure that any water that comes in contact with the crop is microbiologically clean.

Growers should carefully monitor irrigation water and processing water. Selected University Laboratory Services (pages 46-48) lists several water quality laboratories.

Irrigation Water

The quality and safety of irrigation water determines the quality and safety of the produced crop. And the safety of the water depends on its source: is it ground water or surface water. Pathogens can be introduced into irrigation water through manure runoff from animal production facilities, sewage runoff from treatment facilities, or directly from wildlife. Extreme rainfall, manure spills, or human waste can increase the probability of contamination occurring.

Ground water is less likely to be contaminated due to the natural filtration through soil layers. Well water when used directly bears a relatively low contamination risk, provided that well walls are properly constructed and well maintained. Still, there is a potential for contamination if animals frequent the area surrounding the wellhead or sewage leaks into the recharge area. If well walls are fortified with clean soil, with no gaps between the well and soil, runoff will flow away from well.

Surface water (such as ponds, creeks, and rivers) can easily be contaminated by runoff or wildlife. Surface water also has more variable microbial quality and the level of contamination may rapidly change.

If irrigation water comes from a creek or river, consider using a settling pond to control the microbial load. In settling ponds, large particles that contain microorganisms will settle at the bottom. You can also communicate with neighboring livestock producers and work on ways to maximize the distance between livestock and water bodies used for irrigation or other crop production practices like spraying. When possible, build natural buffer zones around water to prevent runoffs.

The quality of water in ponds depends on the original source and on how well the pond is protected from contamination from runoff and wildlife. Ponds filled from groundwater sources have higher quality water than those filled from rivers or ditches. To protect ponds, there are several steps growers can take:

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.

Take special precaution when surface waters may contain sediment and high microbial contamination loads washed in by heavy rain. Remember that bird and rodent feces or dead animals can contaminate rainwater storage tanks. And if improperly treated, recycled municipal wastewater presents a high contamination risk.

To prevent crop contamination, be aware of the microbial quality of water. Periodically test water for the presence of microorganisms that indicate fecal contamination and *E. coli*. The frequency of testing depends on the nature and extent of contamination. The critical limits for *E. coli* depends on the intended use of the water and time to harvest. Currently accepted guidelines call for no more than 126 generic *E. coli* colony forming units (cells) per 100 milliliters of water intended for pre-harvest uses. *E. coli* should be below detectable limits for post-harvest uses (product cleaning, product cooling, etc.)

Growers should also monitor other potential sources of microbial contamination, including application methods, application timing (how close to harvest), and vegetable types. These factors are often interrelated and have to be considered in a combination.
There are various water application methods, including flood irrigation, spray irrigation, drip/trickle irrigation, and sub-irrigation. Flood irrigation may easily spread fecal runoffs and presents a high food safety risk. Drip irrigation comes in contact only with the roots, so the risk of contamination is limited.

When choosing the application method, consider the crop. Vegetables grown closer to the ground are exposed to a greater risk since they can easily contact the contaminant, either through splashed soil or manure during irrigation. Products that are eaten fresh are also at a higher risk, as are vegetables that have large leaf surfaces (such as leafy greens) and vegetables that can trap and hold water.

**Processing Water**

Water is used in many processing operations, including washing produce, cooling, top-icing, and transferring product with flumes. Wash water is a potential source of contamination. Washing fresh produce with contaminated water is one way pathogens can be introduced to and spread throughout a harvest lot. Wash water that is not clean and sanitary can easily transfer pathogens from contaminated to noncontaminated produce.

To prevent contamination, treat wash water. There are a number of chemical and nonchemical sanitizers, including chlorine, chlorine dioxide, peracetic acid, hydrogen peroxide, ozone, and UV light. Your water treatment choice depends on the application and type of product. Seek sound technical advice before investing in a system. Any treatment should be labeled for the intended use. See Table 18 for a list of EPA-registered products for use in produce wash water.

Chlorine is the most common used sanitizer. It reacts with all organic compounds, including bacterial cells that are present in water. However, dirty wash water quickly neutralizes chlorine and render it ineffective against microorganisms. Chlorine is most active when water pH is 6.8-7. Add citric or other organic acids approved for contact with food to reach this pH.

Chlorine’s effectiveness depends on a number of factors, including the initial microorganism load, water temperature, produce type, and contact time between produce and chlorinated water. Monitor chlorine levels to ensure optimal activity. Chlorine activity is optimal when it has an oxidation reduction potential (ORP) of 650 mV or more and a pH 6.8-7.0. You can monitor ORP and pH with a handheld instrument.
Table 18: Sanitizers Approved for Wash or Process Water

These sanitizing agents have been labeled by the U.S. EPA used for use in wash or process water for vegetables. Individuals must check with their respective states to determine if a state label is available.

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Active Ingredient</th>
<th>Company</th>
<th>EPA Reg. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agclor 310°</td>
<td>sodium hypochlorite</td>
<td>Decco</td>
<td>2792-62</td>
</tr>
<tr>
<td>Anthium Dioxide*</td>
<td>chlorine dioxide</td>
<td>International Dioxide</td>
<td>9150-2</td>
</tr>
<tr>
<td>Antimicrobial Fruit &amp; Vegetable Treatment*</td>
<td>lactic acid</td>
<td>Ecolab</td>
<td>1677-234</td>
</tr>
<tr>
<td>Biosafe Disease Control RTU*</td>
<td>hydrogen peroxide</td>
<td>Biosafe Systems</td>
<td>70299-9</td>
</tr>
<tr>
<td>Biosafe Fruit &amp; Vegetable Wash*</td>
<td>hydrogen peroxide</td>
<td>Biosafe Systems</td>
<td>70299-9</td>
</tr>
<tr>
<td>Bioside HS 15%*</td>
<td>peroxyacetic acid</td>
<td>Enviro Tech Chemical Services</td>
<td>63838-2</td>
</tr>
<tr>
<td>Biotrol 150 Antimicrobial Solution*</td>
<td>peroxyacetic acid</td>
<td>U.S. Water Services</td>
<td>63838-2</td>
</tr>
<tr>
<td>Bromide Plus*</td>
<td>sodium bromide</td>
<td>Clearon</td>
<td>8622-49-69470</td>
</tr>
<tr>
<td>Bulah 6040°</td>
<td>sodium bromide</td>
<td>Buckman Laboratories</td>
<td>1448-345</td>
</tr>
<tr>
<td>Carnebon 200°</td>
<td>chlorine dioxide</td>
<td>International Dioxide</td>
<td>9150-3</td>
</tr>
<tr>
<td>Chlorguard Ii*</td>
<td>sodium hypochlorite</td>
<td>Rochester Midland</td>
<td>33981-20001-527</td>
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<tr>
<td>Chlor San 1050°</td>
<td>sodium hypochlorite</td>
<td>Chemstation of Northern Indiana</td>
<td>67649-20001-74373</td>
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<tr>
<td>Chlor-Clean 12.5°</td>
<td>sodium hypochlorite</td>
<td>Madison Chemical</td>
<td>550-198-110</td>
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<tr>
<td>Chlorine Liquified Gas Under Pressure*</td>
<td>chlorine</td>
<td>Olin Chlor Alkali Products</td>
<td>72315-1</td>
</tr>
<tr>
<td>Clearitas 450 Disinfectant, Sanitizer And Cleaner*</td>
<td>sodium hypochlorite</td>
<td>Blue Earth Labs</td>
<td>87437-1</td>
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<tr>
<td>Command*</td>
<td>peroxyacetic acid</td>
<td>Boumatic</td>
<td>63838-1</td>
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<td>Dicasan Paa*</td>
<td>peroxyacetic acid</td>
<td>Dubois Chemicals</td>
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</tr>
<tr>
<td>Environguard Sanitizer*</td>
<td>peroxyacetic acid</td>
<td>Rochester Midland</td>
<td>63838-1</td>
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<tr>
<td>Formula 308°</td>
<td>sodium hypochlorite</td>
<td>Garratt Callahan</td>
<td>33981-20002-8540</td>
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<tr>
<td>Zep Peroxy-Serve 5°</td>
<td>peroxyacetic acid</td>
<td>Zep</td>
<td>63838-1</td>
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<tr>
<td>Hydroxysan Pa No. 480°</td>
<td>peroxyacetic acid</td>
<td>Hydrite Chemical</td>
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<td>Induelor 70°</td>
<td>calcium hypochlorite</td>
<td>Axiall</td>
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<td>KC-610° (Antimicrobial Solution)</td>
<td>peroxyacetic acid</td>
<td>Packers Chemical</td>
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<tr>
<td>MBC 442°</td>
<td>sodium bromide</td>
<td>Nashville Chemical &amp; Equipment</td>
<td>83451-17-44392</td>
</tr>
<tr>
<td>Madison Oxy-San Acid Sanitizer Disinfectant*</td>
<td>peroxyacetic acid</td>
<td>Madison Chemical</td>
<td>63838-12-109</td>
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<tr>
<td>Oakite Liquid Bactericide*</td>
<td>sodium hypochlorite</td>
<td>Chemetall</td>
<td>9359-2-1020</td>
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<tr>
<td>Oxine*</td>
<td>chlorine dioxide</td>
<td>Bio Cide International</td>
<td>9804-1</td>
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<td>Oxywave*</td>
<td>peroxyacetic acid</td>
<td>Madison Chemical</td>
<td>63838-1</td>
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<tr>
<td>Peraclean 15°</td>
<td>peroxyacetic acid</td>
<td>Evonik Corporation</td>
<td>54289-4</td>
</tr>
<tr>
<td>Peraclean 5°</td>
<td>peroxyacetic acid</td>
<td>Evonik Corporation</td>
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<tr>
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<td>peroxyacetic acid</td>
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</tr>
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<td>peroxyacetic acid</td>
<td>Zep</td>
<td>63838-1</td>
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<tr>
<td>Premium Peroxide Li*</td>
<td>peroxyacetic acid</td>
<td>West Agro</td>
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<td>Sanidate 5.0°</td>
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<td>Biosafe Systems</td>
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<td>Sanidate 12.0°</td>
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<td>Biosafe Systems</td>
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<tr>
<td>Selectrocide 21500°</td>
<td>chlorine dioxide</td>
<td>Selective Micro Technologies</td>
<td>74986-4</td>
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<tr>
<td>Selectrocide 12G *</td>
<td>chlorine dioxide</td>
<td>Selective Micro Technologies</td>
<td>74986-5</td>
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<tr>
<td>Sno-Glo Bleach*</td>
<td>sodium hypochlorite</td>
<td>Brenntag Mid-South</td>
<td>6785-20002</td>
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<td>SOBR 2°</td>
<td>sodium bromide</td>
<td>Buckman Laboratories</td>
<td>1448-345</td>
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<td>Sodium Hypochlorite - 12.5 Bacticide*</td>
<td>sodium hypochlorite</td>
<td>Olin Chlor Alkali Products</td>
<td>72315-6</td>
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<td>Sodium Hypochlorite 12.5°*</td>
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<td>Alexander Chemical</td>
<td>7151-20001</td>
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<tr>
<td>Sodium Hypochlorite Solution 12.5%*</td>
<td>sodium hypochlorite</td>
<td>K A Steel Chemicals</td>
<td>33981-20001</td>
</tr>
<tr>
<td>Sysco Classic Germicidal Ultra Bleach*</td>
<td>sodium hypochlorite</td>
<td>Sysco</td>
<td>70271-13-29055</td>
</tr>
<tr>
<td>Tsunami 100°</td>
<td>peroxyacetic acid</td>
<td>Ecolab Food &amp; Beverage Division</td>
<td>1677-164</td>
</tr>
<tr>
<td>Vertex Concentrate*</td>
<td>sodium hypochlorite</td>
<td>Vertex Chemical</td>
<td>9616-8</td>
</tr>
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<td>Vertex CSS-10°</td>
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<td>Vertex Chemical</td>
<td>9616-8</td>
</tr>
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<td>Vertex CSS-12°</td>
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<td>Vertex Chemical</td>
<td>9616-7</td>
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<td>Vertex CSS-5°</td>
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<td>Vertex Chemical</td>
<td>9616-10</td>
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<td>Victory*</td>
<td>hydrogen peroxide</td>
<td>Ecolab Institutional Div Ecolab Center</td>
<td>1677-186</td>
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<td>Vigorox 15 F&amp;V *</td>
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<td>FMC</td>
<td>65402-3</td>
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<tr>
<td>Vigorox SP-15 Antimicrobial Agent*</td>
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<td>FMC</td>
<td>65402-3</td>
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<tr>
<td>WSU Sodium Hypochlorite 12.5%*</td>
<td>sodium hypochlorite</td>
<td>Water Solutions Unlimited</td>
<td>33981-20001-83327</td>
</tr>
<tr>
<td>Zep FS Formula 4665 *</td>
<td>sodium hypochlorite</td>
<td>Zep</td>
<td>1270-20001</td>
</tr>
</tbody>
</table>
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 ANRCatalog, anrcatalog.ucdavis.edu.

More information about GAPs is available in:
- Food Safety for Fruit and Vegetable Farms, ag.purdue.edu/hla/foodsafety/Pages/default.aspx.

**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.

**Preventative 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.
### Table 19: Preharvest Intervals (Days) and Re-Entry Intervals (Hours) for Insecticides/Acaricides Registered for Use on Midwest Vegetables 2017

| Insecticides/Acaricides | Asparagus | Broccoli | Brussels Sprouts | Cabbage | Cantaloupe | Carrot | Cauliflower | Celery | Chinese Cabbage | Collard | Cucumber | Eggplant | Endive | Green Onion | Head Lettuce | Kale | Kidney Bean | Leaf Lettuce | Lima Bean | Mint | Mustard | Okra | Onion Bulb | Parsley | Parsnip | Peas | Pepper | Potato | Pumpkin | Radish | Rhubarb | Rutabaga | Snap Bean | Spinach | Summer Squash | Sweet Corn | Sweet Potato | Tomato | Turnip | Watermelon | Winter Squash | Re-Entry Intervals (hours) |
|-------------------------|-----------|----------|-----------------|---------|------------|--------|-------------|-------|---------------|---------|-----------|-----------|--------|------------|-------------|------|------------|------------|---------|-------|--------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Danitol®                | 1         | 0        | 0               | 3       | 0          | 3      | 0           | X     | 0             | 0       | 0         | 0         | 0      | 0           |             | 7    | 7          | 0          | 0       | 0      | 0      | 0      | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Radiant®               | 1         | 0        | 0               | 3       | 0          | 3      | 0           | X     | 0             | 0       | 0         | 0         | 0      | 0           |             | 7    | 7          | 0          | 0       | 0      | 0      | 0      | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Voliam Xpress          | 1         | 0        | 0               | 3       | 0          | 3      | 0           | X     | 0             | 0       | 0         | 0         | 0      | 0           |             | 7    | 7          | 0          | 0       | 0      | 0      | 0      | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Warrior®               | 1         | 0        | 0               | 3       | 0          | 3      | 0           | X     | 0             | 0       | 0         | 0         | 0      | 0           |             | 7    | 7          | 0          | 0       | 0      | 0      | 0      | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |

X=check label for details.

1 Check label directions before applying any of these pesticides.
Plant Parasitic Nematode Management Strategies

Disease Diagnosis

Plant parasitic nematode management hinges on detection and population density estimation. Before selecting a field for vegetable production, submit a soil sample to a lab with a trained nematologist to analyze the soil for the presence and quantity of plant parasitic nematodes. Root-knot nematodes (*Meloidogyne* spp.) and soybean cyst nematodes (*Heterodera glycines*) are the most important nematode pests commonly found in the Midwest.

Disease-resistant Varieties

Resistance to *Meloidogyne incongrita* is available with the Mi gene in tomato, but few other vegetable crops presently have resistant genes for root-knot nematodes. Nematode resistance in tomatoes is indicated by the “N” designation. Resistant varieties should be used whenever possible to reduce yield loss. It is important to have multiple disease resistance genes when more than one important pathogen is present in a field, such as with tomatoes where root-knot nematodes, Verticillium, and Fusarium can interact.

Crop Rotation

Plant parasitic nematodes overwinter in the soil or in association with plant material. Crop rotation and weed control are very important in managing plant parasitic nematodes. Root-knot nematodes have a very wide vegetable, field crop, and weed host range. Soybean cyst nematodes have a much narrower host range, but when both nematode species are present, a rotation ideal for soybean cyst nematode reduction may favor buildup of root-knot nematodes.

Other Cultural Practices

Adequate water and fertilizer can minimize plant parasitic nematode damage. Plant parasitic nematodes reduce the plant root system’s ability to take up water and nutrients. Adequate water and fertilizer do not reduce nematode density but help plants to cope better with nematode damage, and might increase yield and reduce the symptoms of nematode damage.

Anything that moves soil can spread plant parasitic nematodes to other fields and within the same field. Thus, preventing infested soil and plant material from infesting fields will help with nematode management.

Chemical Control

Seedling diseases, root diseases, and vascular wilts caused by soilborne fungi and nematodes can be destructive problems in the field and greenhouse. Soil-applied fumigants or nematicides may help prevent serious losses to soilborne disease when combined with long-term management practices.

Soil fumigants are chemicals that are injected into the soil and emit toxic fumes that penetrate air spaces in the soil and kill microorganisms. Fumigants must be sealed into the soil with water or a plastic tarp to ensure that a lethal concentration and exposure time. Because fumigants are harmful to all living plants, a certain amount of time (from two weeks to two months) must pass between treatment and planting to avoid crop damage. Several nonfumigant nematicides are available for several vegetable crops. These generally are systemic compounds that also may provide good insect control.

A number of factors affect the performance of these products, including soil temperature, soil moisture, soil tilth, organic matter, soil type, and time of application. Consult the product label for specific details on safe handling and application methods.

A brief description of several common soil treatments is given in Table 20.
## Table 20: Nematode Soil Treatments

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Fumigant/ Nematicide</th>
<th>Application</th>
<th>Plant Back Time</th>
<th>Crops</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mocap*, ethroprop (RUP)</td>
<td>N</td>
<td>Soil only. Applied with water by soil injection, sprinkler system, flood irrigation, over soil surface with sprinkling can.</td>
<td>NA</td>
<td>cabbage, sweet corn, cucumbers, potatoes, sweet potatoes, snap beans, lima beans</td>
<td>Mobile in sand soils. Crop injury can occur if used in furrow.</td>
</tr>
<tr>
<td>Nemacur*, fenamiphos (RUP)</td>
<td>N</td>
<td>Soil treatment only.</td>
<td>NA</td>
<td>cabbage, Brussels sprouts, bok choy, okra, garlic</td>
<td></td>
</tr>
<tr>
<td>Nimitz*</td>
<td>N</td>
<td>Soil treatment only. Broadcast, band, or drip applications.</td>
<td>7 days</td>
<td>cucurbits, pepper.</td>
<td>Contact pesticide. Caution label.</td>
</tr>
<tr>
<td>SMDC: sodium methyldithiocarbamate (Vapam*, etc.)</td>
<td>F</td>
<td>Preplant tarped. Don't enter within 48 hours.</td>
<td>14-21 days after treatment</td>
<td>general use fumigant</td>
<td>Vapam is more effective when applied with considerable water.</td>
</tr>
<tr>
<td>Vydate* (RUP)</td>
<td>N</td>
<td>Soil and foliage treatment.</td>
<td>NA</td>
<td>carrots, celery, cucurbits, eggplants, peppers, potatoes, sweet potatoes, tomatoes</td>
<td>Foliar applications are not effective for moderate and high populations of nematodes.</td>
</tr>
<tr>
<td>Telone* (RUP)</td>
<td>F</td>
<td>Soil treatment only.</td>
<td>2-3 weeks</td>
<td>most vegetables</td>
<td>Formulations with high percentages chloropicrin are needed to control soilborne fungal diseases.</td>
</tr>
</tbody>
</table>

F=fumigant  
N=nematicide  
RUP=restricted use pesticide

Belowground symptoms of root knot nematodes include roots with enlarged galls.
Weed Management

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 Table 21).

Table 21: Botanically Related Vegetables

<table>
<thead>
<tr>
<th>Alliums</th>
<th>Corn</th>
<th>Cucurbit</th>
<th>Crucifer</th>
<th>Goosefoot Family</th>
<th>Legume</th>
<th>Nightshade Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chive</td>
<td>Dent corn</td>
<td>Cantaloupe</td>
<td>Cabbage</td>
<td>Beet</td>
<td>Dry bean</td>
<td>Eggplant</td>
</tr>
<tr>
<td>Garlic</td>
<td>Sweet corn</td>
<td>Cucumber</td>
<td>Cauliflower</td>
<td>Chard</td>
<td>Lima bean</td>
<td>Pepper</td>
</tr>
<tr>
<td>Leek</td>
<td></td>
<td>Pumpkin</td>
<td>Broccoli</td>
<td>Spinach</td>
<td>Pea</td>
<td>Potato</td>
</tr>
<tr>
<td>Onion</td>
<td></td>
<td>Summer squash</td>
<td>Brussels sprout</td>
<td></td>
<td>Snap bean</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Watermelon</td>
<td>Horseradish</td>
<td></td>
<td>Soybean</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Winter squash</td>
<td>Kale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Radish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rutabaga</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

59
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. Table 22 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.

| Table 22: Classification of Vegetable Crops According to Their Adaptive Field Temperatures |
|-----------------------------------------------|---|---|---|
| Cool-season | Semi-Hardy | Tender | Very Tender |
| Hardy | | | |
| 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 |
| Spinach | | | Watermelon |

1Hardy 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.

Table 23 summarizes some nonchemical weed management practices (see page 64). 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), the Pest Management and Crop Development Bulletin (bulletin.ipm.illinois.edu), the Indiana Vegetable Crops Hotline (vegcropshotline.org), or the Weed Control Guide for Vegetable Crops (Michigan State University Extension publication E-0433, available at 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. Table 24 summarizes some of the label restrictions (see page 65) 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®), 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®, Permit®, Matrix®, Raptor®, and Pursuit® 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®, and Sinbar® 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® and Treflan®. 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.
Table 23: Summary of Nonchemical Weed Management Practices

<table>
<thead>
<tr>
<th>Cultural</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Land selection</td>
<td>Avoid fields with a history of weed problems.</td>
</tr>
<tr>
<td>Crop selection</td>
<td>Grow the most competitive crops in fields with histories of weed problems.</td>
</tr>
<tr>
<td>Crop rotation</td>
<td>Rotate between vegetables and non-row crops such as alfalfa. Rotate between vegetables in different botanical categories.</td>
</tr>
<tr>
<td>Adapted crop varieties</td>
<td>Select crop varieties adapted for your area.</td>
</tr>
<tr>
<td>Proper row spacings and plant densities</td>
<td>Use row spacings and plant densities that assure rapid crop canopy closure.</td>
</tr>
<tr>
<td>Correct planting times</td>
<td>Plant crops when soil temperatures favor rapid germination and emergence. Do not plant warm-season crops too early in the season.</td>
</tr>
<tr>
<td>Appropriate crop management</td>
<td>Vigorous, healthy crops are more competitive against weeds and insects.</td>
</tr>
<tr>
<td>Mulch</td>
<td>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.</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Mechanical and Thermal</th>
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<tr>
<td>Moldboard plowing</td>
<td>This can eliminate emerged annual weeds.</td>
</tr>
<tr>
<td>Rotary hoeing</td>
<td>This is useful to manage small-seeded weeds in large-seeded crops such as sweet corn, snap bean, lima bean, and pea.</td>
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<tr>
<td>Row cultivator</td>
<td>Dislodge or cover as many weed seedlings as possible. Avoid damaging crop root systems.</td>
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<tr>
<td>Mowing</td>
<td>Mow weeds as soon as flowers appear so no viable weed seed is produced.</td>
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<tr>
<td>Flame weeding</td>
<td>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.</td>
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<table>
<thead>
<tr>
<th>Biological</th>
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<tr>
<td>Cover crops and living mulches</td>
<td>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.</td>
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<tr>
<td>Insect or disease pests or weeds</td>
<td>No current systems use insects or diseases to manage weeds in common vegetables.</td>
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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.
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<tr>
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<th>Pea</th>
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*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.
*Transplanted tomatoes only.
*In Indiana, the replant restriction for transplanted tomatoes and peppers, cabbage, melons, and cucumbers is 18 months.
## Table 25: Relative Effectiveness of Herbicides for Vegetable Crops

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<tr>
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<th>Landscape</th>
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1. For pre-packaged mixtures, see ratings for individual components.
2. Excellent against grassy substitute.
3. Post-directed spray.
Table 26: Preharvest Intervals (Days) and Entry Intervals (Hours) for Herbicides Registered for Use on Midwest Vegetables in 2017

| Herbicide | Asparagus | Beet | Broccoli | Cabbage | Cantaloupe | Carrot | Cauliflower | Collard | Cucumber | Dry Bean | Eggplant | Endive/Escarole | Garlic | Horseradish | Kale | Leek | Lettuce | Lima Bean | Mint | Mustard | Okra | Onion, dry bulb | Onion, green bunching | Parsley | Parsnip | Pea | Pepper | Potato | Pumpkin | Radish | Rhubarb | Snap Bean | Spinach | Squash | Sweet Corn | Sweet Potato | Tomato | Turnip, greens | Turnip, root | Watermelon | Re-Entry Intervals (hours) |
|-----------|-----------|------|----------|---------|-----------|--------|-------------|---------|----------|---------|----------|---------------|--------|-------------|------|------|--------|----------|------|----------|-----|---------|-------------------|-----------------|---------|----------------|--------------|------------|-----------------|-----------------|----------------|
|           | X         |      | X        | X       | X         | X      | X           | X       | X        | X       | X        | X              |       | X           | X    | X     | X      | X        | 40   | X        | X    |         | X                 |                 | X       | X              | X             | X          | X               | X               | X          | 48          |
| 2,4-D     |           |      |          |         |           |        | X           | X       | X        | X       | X        | X              |       | X           | X    | X     | X      | X        | 30   | X        | X    |         | X                 |                 | X       | X              | X             | X          | X               | X               | X          | 12          |
| acetochlor|           |      |          |         |           |        | X           |         | X        | X       | X        | X              |       | X           | X    | X     | X      | X        | 30   | X        | X    |         | X                 |                 | X       | X              | X             | X          | X               | X               | X          | 12          |
| acetochlor+atrazine | Acuron ® |      |          |         |           |        | X           |         | X        | X       | X        | X              |       | X           | X    | X     | X      | X        | 40   | X        | X    |         | X                 |                 | X       | X              | X             | X          | X               | X               | X          | 12          |
| Ailin® | acetochlor |      |          |         |           |        | X           |         | X        | X       | X        | X              |       | X           | X    | X     | X      | X        | 45   | X        | X    |         | X                 |                 | X       | X              | X             | X          | X               | X               | X          | 12          |
| Ailin® | alachlor |      |          |         |           |        | X           |         | X        | X       | X        | X              |       | X           | X    | X     | X      | X        | 45   | X        | X    |         | X                 |                 | X       | X              | X             | X          | X               | X               | X          | 12          |
| Ailin® | AnthraMix® |      |          |         |           |        | X           |         | X        | X       | X        | X              |       | X           | X    | X     | X      | X        | 70   | X        | X    |         | X                 |                 | X       | X              | X             | X          | X               | X               | X          | 50          |
| Ailin® | Assure L® |      |          |         |           |        | X           |         | X        | X       | X        | X              |       | X           | X    | X     | X      | X        | X    | X        | X    |         | X                 |                 | X       | X              | X             | X          | X               | X               | X          | 45          |
| Ailin® | atrazine |      |          |         |           |        | X           |         | X        | X       | X        | X              |       | X           | X    | X     | X      | X        |      | X        | X    |         | X                 |                 | X       | X              | X             | X          | X               | X               | X          | 14          |

continued next page
### Table 26 (continued)

|----------------------|--------------|---------|-------|-------|----------|-----------|----------|------------|----------|----------|-----------|------------|-----------|-----------|---------|-----------|------------------------|--------|------|---------|----------|----------|------------------------|----------|-----------|----------|-----------|--------|---------|---|
| Asparagus            | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Beet                 |              |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Broccoli             | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Cabbage              |              |         |       | X      |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Cantaloupe           | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Carrot               | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Cauliflower          |              |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Collard              | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Cucumber             | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Dry Bean             | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Eggplant             | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Endive/Escarole      | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Garlic               |              |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Horseradish          | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Kale                 | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Leek                 | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Lettuce              | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Lima Bean            | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Mint                 | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Mustard              | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Okra                 | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Onion, dry bulb      | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Onion, green bunching| X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Parsley              | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Parsnip              | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Pea                  | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Pepper               | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Potato               | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Pumpkin              | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Radish               | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Rhubarb              | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Snap Bean            | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Spinach              | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Squash               | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Sweet Corn           | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Sweet Potato         | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Tomato               | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Turnip, greens       | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Turnip, root         | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Watermelon           | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-
| Re-Entry Intervals   | X            |         |       |       |          |           |          |            |          |          |           |            |           |           |         |           |                        |       |      |         |          |          |                        |         |           |          |           |        |         |-

X=check label for details.

*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 these 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 downy mildews that we often discuss as fungi are not true fungi, they are a different type of organism called an oomycete. 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 absolutely no 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, and others). 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 46-48.

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. Table 27 (page 72) 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 a you suspect a disease on received plants, take photos and contact a diagnostic laboratory (pages 46-48), 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. Table 27 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. Table 27 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. Table 21 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) is often 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.

**Scouting and Sanitation**

Depending on the disease and the size of your operation, you can and should 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 remove 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 disinfest them. Disinfect tools frequently, such as at the end of rows. Avoid working fields under wet conditions.

**Other Cultural Practices**

Other practices can disrupt the life cycle of plant pathogens and reduce the risk of disease. For example, altering planting times can reduce the risk of certain diseases by timing crop development such that the plants are less susceptible when the pathogens are most active.

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 Table 27 (page 72) lists some of these practices. See the Insect Management section (pages 53-56) 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 112).

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.

Table 29 (page 76) 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. Table 20 describes nematode soil treatments.
Table 27: 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.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Disease</th>
<th>Tillage</th>
<th>Seedborne</th>
<th>Rotation</th>
<th>Resistance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allium garlic, onion, leek</td>
<td>Alternaria purple blotch, Botrytis leaf blight</td>
<td>3</td>
<td>Yes</td>
<td>3-4</td>
<td>No</td>
<td>Thrips-damaged tissues are more susceptible</td>
</tr>
<tr>
<td></td>
<td>Aster yellows</td>
<td>1</td>
<td>Yes</td>
<td>NE</td>
<td>No</td>
<td>Seed transmission is low, but possible; transmission from garlic bulb/cloves occurs</td>
</tr>
<tr>
<td></td>
<td>Botrytis neck rot</td>
<td>2</td>
<td>No</td>
<td>3</td>
<td>No</td>
<td>Cure bulbs rapidly and properly and avoid injury to neck</td>
</tr>
<tr>
<td></td>
<td>Downy mildew</td>
<td>2</td>
<td>Yes</td>
<td>3</td>
<td>Yes</td>
<td>Resistance in onion only (limited varieties)</td>
</tr>
<tr>
<td></td>
<td>Fusarium basal rot</td>
<td>1</td>
<td>No</td>
<td>4</td>
<td>Yes</td>
<td>Transmitted on sets and transplants</td>
</tr>
<tr>
<td></td>
<td>Smut</td>
<td>1</td>
<td>No</td>
<td>3</td>
<td>No</td>
<td>Do not move Allium spp. into quarantine areas of the U.S. (Columbia Basin)</td>
</tr>
<tr>
<td></td>
<td>White rot</td>
<td>1</td>
<td>No</td>
<td>NE</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Asparagus</td>
<td>Cercospora leaf spot and rust</td>
<td>NA</td>
<td>No</td>
<td>NA</td>
<td>Yes</td>
<td>Remove or burn down ferns in the late fall to reduce inoculum</td>
</tr>
<tr>
<td></td>
<td>Fusarium crown and root rot</td>
<td>NA</td>
<td>Yes</td>
<td>NA</td>
<td>Yes</td>
<td>Avoid long harvest periods to maintain vigor</td>
</tr>
<tr>
<td></td>
<td>Phytophthora crown and spear rot</td>
<td>NA</td>
<td>No</td>
<td>NA</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Cruciferous vegetables</td>
<td>Alternaria leaf spot</td>
<td>3</td>
<td>Yes</td>
<td>3-4</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Black leg</td>
<td>3</td>
<td>Yes</td>
<td>3-5</td>
<td></td>
<td>Leave 1/4-mile buffer from previously infected fields, delay plant until conditions are dry</td>
</tr>
<tr>
<td></td>
<td>Black rot</td>
<td>3</td>
<td>Yes</td>
<td>2-3</td>
<td>No</td>
<td>Club root pathogen survives on some grass, clover, weedy, and other plants, which influences rotation or cover crop selection</td>
</tr>
<tr>
<td></td>
<td>Club root</td>
<td>NE</td>
<td>No</td>
<td>5-7</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Downy mildew</td>
<td>3</td>
<td>Yes</td>
<td>2-3</td>
<td>Yes</td>
<td>Resistance in broccoli only</td>
</tr>
<tr>
<td></td>
<td>Fusarium yellows</td>
<td>2</td>
<td>Yes</td>
<td>&gt;6</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Powdery mildew</td>
<td>3</td>
<td>No</td>
<td>3</td>
<td>Yes</td>
<td>Resistance for Brussels sprout and cabbage only, avoid over applying nitrogen and drought</td>
</tr>
<tr>
<td></td>
<td>Rhizoctonia diseases</td>
<td>3</td>
<td>No</td>
<td>NE</td>
<td>No</td>
<td>Can form disease complex with black leg pathogen for stem canker</td>
</tr>
<tr>
<td></td>
<td>Sclerotinia stem rot</td>
<td>2</td>
<td>No</td>
<td>NE</td>
<td>No</td>
<td>Very wide host range; rotation for greater than 3 years into grasses, onions, or corn may reduce severe infestations</td>
</tr>
<tr>
<td></td>
<td>White rust</td>
<td>NE</td>
<td>Yes</td>
<td>3</td>
<td>Yes</td>
<td>Remove crop debris from area after harvest</td>
</tr>
<tr>
<td>Table 27: Summary of Cultural Management Strategies for Disease (continued)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cucurbits</strong> (cantaloupe, cucumber, pumpkin, squash, watermelon)</td>
<td>Alternaria leaf blight</td>
<td>3</td>
<td>No</td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Angular leaf spot</td>
<td>3</td>
<td>Yes</td>
<td>2</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anthracnose</td>
<td>3</td>
<td>Yes</td>
<td>2</td>
<td>No</td>
<td>Race 1 affects mainly cucumber, Race 2 affects mainly watermelon</td>
</tr>
<tr>
<td></td>
<td>Bacterial fruit blotch</td>
<td>3</td>
<td>Yes</td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bacterial leaf spot</td>
<td>3</td>
<td>Yes</td>
<td>2</td>
<td>No</td>
<td>Primarily on pumpkin and squash</td>
</tr>
<tr>
<td></td>
<td>Bacterial wilt</td>
<td>1</td>
<td>No</td>
<td>NE</td>
<td>No</td>
<td>Spread by cucumber beetles</td>
</tr>
<tr>
<td></td>
<td>Downy mildew</td>
<td>1</td>
<td>No</td>
<td>NE</td>
<td>Yes</td>
<td>Resistant varieties of cucumber and cantaloupe available</td>
</tr>
<tr>
<td></td>
<td>Fusarium wilt</td>
<td>1</td>
<td>Yes</td>
<td>5-7</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gummy stem blight/black rot</td>
<td>3</td>
<td>Yes</td>
<td>3</td>
<td>No</td>
<td>Also affects pumpkin and watermelon</td>
</tr>
<tr>
<td></td>
<td>Phytophthora blight</td>
<td>2</td>
<td>No</td>
<td>&gt;4</td>
<td>No</td>
<td>Avoid excess water and rotation with solanaceous crops; good drainage is important</td>
</tr>
<tr>
<td></td>
<td>Plectosporium blight</td>
<td>3</td>
<td>No</td>
<td>3-4</td>
<td>No</td>
<td>Primarily on pumpkins; manage like black rot</td>
</tr>
<tr>
<td></td>
<td>Powdery mildew</td>
<td>2</td>
<td>No</td>
<td>2</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Root knot nematode</td>
<td>2</td>
<td>No</td>
<td>&gt;6</td>
<td>No</td>
<td>Wide host range will affect rotation choices</td>
</tr>
<tr>
<td></td>
<td>Viruses (several)</td>
<td>1</td>
<td>No</td>
<td>NE</td>
<td>No</td>
<td>Spread by aphids; plant crops before insect pressure becomes severe</td>
</tr>
<tr>
<td><strong>Leafy vegetables</strong> (endive, herbs, lettuce, spinach)</td>
<td>Botrytis gray mold</td>
<td>2</td>
<td>No</td>
<td>NE</td>
<td>No</td>
<td>Provide adequate spacing to reduce humidity</td>
</tr>
<tr>
<td></td>
<td>Bottom rot and drop</td>
<td>2</td>
<td>No</td>
<td>NE</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Downy mildew, white rust</td>
<td>NE</td>
<td>Yes</td>
<td>3</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lettuce mosaic virus</td>
<td>2</td>
<td>Yes</td>
<td>1</td>
<td>Yes</td>
<td>There are many hosts that may harbor the virus; manage aphid populations</td>
</tr>
<tr>
<td></td>
<td>Powdery mildew</td>
<td>2</td>
<td>No</td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td><strong>Legumes</strong> (cowpea, dry bean, lima bean, pea, snap bean)</td>
<td>Anthracnose</td>
<td>3</td>
<td>Yes</td>
<td>3</td>
<td>Yes</td>
<td>Resistance is race-dependent</td>
</tr>
<tr>
<td></td>
<td>Bacterial blights</td>
<td>3</td>
<td>Yes</td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rust</td>
<td>1</td>
<td>No</td>
<td>3-4</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soybean cyst nematode</td>
<td>1</td>
<td>No</td>
<td>1-3</td>
<td>No</td>
<td>Rotation interval depends on the cyst count in soil samples</td>
</tr>
<tr>
<td></td>
<td>White mold and gray mold</td>
<td>2</td>
<td>No</td>
<td>NE</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td><strong>Root crops</strong> (beet, carrot, parsnip, radish, turnip)</td>
<td>Aster yellows</td>
<td>2</td>
<td>Yes</td>
<td>NE</td>
<td>No</td>
<td>Seed transmission is low, but possible; destroy perennial weed hosts near high-value crops</td>
</tr>
<tr>
<td></td>
<td>Cercospora leaf spot, Alternaria leaf blight</td>
<td>3</td>
<td>Yes</td>
<td>2</td>
<td>Yes</td>
<td>Resistance availability varies by root crop and pathogen</td>
</tr>
<tr>
<td></td>
<td>Downy mildew, white rust</td>
<td>3</td>
<td>Yes</td>
<td>3</td>
<td>No</td>
<td>Cruciferous weeds and crops are also hosts</td>
</tr>
<tr>
<td></td>
<td>Root knot nematode</td>
<td>2</td>
<td>No</td>
<td>&gt;6</td>
<td>No</td>
<td>Wide host range affects rotational options</td>
</tr>
<tr>
<td></td>
<td>White mold</td>
<td>2</td>
<td>No</td>
<td>NE</td>
<td>No</td>
<td>Avoid rotation with beans, cucurbits, celery, and cabbage</td>
</tr>
</tbody>
</table>
Table 27: Summary of Cultural Management Strategies for Disease (continued)

<table>
<thead>
<tr>
<th>Crop Category</th>
<th>Disease Name</th>
<th>Rating</th>
<th>Control</th>
<th>Years to Recover</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet corn</td>
<td>Anthracnose</td>
<td>3</td>
<td>No</td>
<td>1-3</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Goss’ wilt</td>
<td>3</td>
<td>Yes</td>
<td>1</td>
<td>Partial</td>
</tr>
<tr>
<td></td>
<td>Control grassy weeds that are hosts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leaf blights (southern corn leaf</td>
<td>3</td>
<td>No</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>blight, northern corn leaf blight,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>northern corn leaf spot)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rust</td>
<td>NE</td>
<td>No</td>
<td>NE</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Smut</td>
<td>2</td>
<td>No</td>
<td>NE</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Stewart’s wilt</td>
<td>1</td>
<td>Yes</td>
<td>NE</td>
<td>Partial</td>
</tr>
<tr>
<td></td>
<td>Spreads and survives in flea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>beetles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruiting vegetables</td>
<td>Anthracnose</td>
<td>3</td>
<td>Yes</td>
<td>3-4</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Disease is systemic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bacterial canker</td>
<td>3</td>
<td>Yes</td>
<td>3-4</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Disease is systemic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bacterial speck</td>
<td>3</td>
<td>Yes</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Some strains are copper resistant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bacterial spot</td>
<td>3</td>
<td>Yes</td>
<td>2-3</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Copper resistance reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Early blight</td>
<td>3</td>
<td>Yes</td>
<td>3-4</td>
<td>Partial</td>
</tr>
<tr>
<td></td>
<td>Some resistance to stem canker</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fusarium crown and root rot</td>
<td>2</td>
<td>Yes</td>
<td>&gt;6</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Graft to resistant root stocks; use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>resistant varieties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Late blight</td>
<td>1</td>
<td>No</td>
<td>NE</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Does not overwinter in the Midwest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leaf mold</td>
<td>2</td>
<td>Yes</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Notably a problem in high tunnels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and greenhouses; infected transplants will experience disease outdoors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Powdery mildew</td>
<td>2</td>
<td>No</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Root knot nematode</td>
<td>2</td>
<td>No</td>
<td>&gt;6</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Wide host range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Septoria leaf spot</td>
<td>3</td>
<td>No</td>
<td>2-3</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Southern blight</td>
<td>3</td>
<td>No</td>
<td>&gt;6</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Favored by high temperatures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tobacco mosaic virus</td>
<td>1</td>
<td>No</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Spread by contact</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tomato spotted wilt virus</td>
<td>1</td>
<td>No</td>
<td>NE</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Spread by thrips</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Verticillium</td>
<td>2</td>
<td>No</td>
<td>&gt;6</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>White mold</td>
<td>2</td>
<td>No</td>
<td>5-6</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Wide host range; rotate with grasses; flood for 23-45 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All vegetables</td>
<td>Damping-off</td>
<td>1</td>
<td>No</td>
<td>NE</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Avoid excess moisture, sanitize seedling trays</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1=tillage has limited effect, 2=tillage is of limited help, 3=tillage is an important control
2=Numbers refer to the number of years that the field should be planted to a different crop. NE=not effective.
Table 28: Preharvest Intervals (Days) and Re-Entry Intervals for Fungicides Registered for Use on Midwest Vegetables in 2017

<table>
<thead>
<tr>
<th>Fungicide Name</th>
<th>Re-Entry Interval (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asparagus</td>
<td>12</td>
</tr>
<tr>
<td>Bean, Dry</td>
<td>12</td>
</tr>
<tr>
<td>Bean, Green</td>
<td>12</td>
</tr>
<tr>
<td>Beet</td>
<td>12</td>
</tr>
<tr>
<td>Broccoli</td>
<td>12</td>
</tr>
<tr>
<td>Brussels Sprouts</td>
<td>12</td>
</tr>
<tr>
<td>Cabbage</td>
<td>12</td>
</tr>
<tr>
<td>Cabbage, Chinese</td>
<td>12</td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>12</td>
</tr>
<tr>
<td>Carrot</td>
<td>12</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>12</td>
</tr>
<tr>
<td>Celery</td>
<td>12</td>
</tr>
<tr>
<td>Collard</td>
<td>12</td>
</tr>
<tr>
<td>Cucumber</td>
<td>12</td>
</tr>
<tr>
<td>Eggplant</td>
<td>12</td>
</tr>
<tr>
<td>Endive</td>
<td>12</td>
</tr>
<tr>
<td>Kale</td>
<td>12</td>
</tr>
<tr>
<td>Lettuce, Head</td>
<td>12</td>
</tr>
<tr>
<td>Lettuce, Leaf</td>
<td>12</td>
</tr>
<tr>
<td>Mint</td>
<td>12</td>
</tr>
<tr>
<td>Mustard</td>
<td>12</td>
</tr>
<tr>
<td>Onion, Bulb</td>
<td>12</td>
</tr>
<tr>
<td>Onion, Green</td>
<td>12</td>
</tr>
<tr>
<td>Parsley</td>
<td>12</td>
</tr>
<tr>
<td>Parsnip</td>
<td>12</td>
</tr>
<tr>
<td>Peas</td>
<td>12</td>
</tr>
<tr>
<td>Pepper</td>
<td>12</td>
</tr>
<tr>
<td>Potato</td>
<td>12</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>12</td>
</tr>
<tr>
<td>Radish</td>
<td>12</td>
</tr>
<tr>
<td>Spinach</td>
<td>12</td>
</tr>
<tr>
<td>Squash, Summer</td>
<td>12</td>
</tr>
<tr>
<td>Squash, Winter</td>
<td>12</td>
</tr>
<tr>
<td>Sweet Corn</td>
<td>12</td>
</tr>
<tr>
<td>Tomato</td>
<td>12</td>
</tr>
<tr>
<td>Turnip</td>
<td>12</td>
</tr>
<tr>
<td>Watermelon</td>
<td>12</td>
</tr>
</tbody>
</table>

*Check label directions before applying any of these pesticides.

1. See label.
2. Do not apply past peak bloom.
3. 0-day PHI for Napa Chinese cabbage. 14-day PHI for bok choy.
4. 0-day PHI for bok choy. 7-day PHI for napa.
5. Succulent only. 7-day PHI.

*Chile only.

1. Do not use Penncozeb.
2. Do not use Propimax.
3. Phosphite only.

*describes a wettable powder product that is 53% metallic copper, and "4.5F" describes a flowable product containing 4.5 lbs. of metallic copper per gallon.
### Table 29: Fungicide Resistance Management

Disease-causing fungi may become resistant to fungicides if label precautions are not followed carefully. This table is designed to help growers alternate applications between fungicides with different modes of action to avoid or delay development of fungicide resistance in fungi. Many product labels use the same letters and numbers as those listed in the MOA Code column below. This list is not exhaustive, but does contain many of the fungicides used in the Midwest.

<table>
<thead>
<tr>
<th>Trade Names</th>
<th>Common Name</th>
<th>Risk of Resistance</th>
<th>MOA Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actigard*</td>
<td>acibenzolar-S-methyl</td>
<td>none-low</td>
<td>21²</td>
</tr>
<tr>
<td>Agri-Fos*, Phostrol*</td>
<td>phosphorous acid</td>
<td>low</td>
<td>NA³</td>
</tr>
<tr>
<td>Aliette*</td>
<td>fosetyl-A1</td>
<td>low</td>
<td>M</td>
</tr>
<tr>
<td>Aprovia Top *</td>
<td>benzovindiflupyr (7), difenconazole (3)</td>
<td>medium</td>
<td>7, 3</td>
</tr>
<tr>
<td>Bravo*, Echo*, Equus*</td>
<td>chlorothalonil</td>
<td>none-low</td>
<td>M⁴</td>
</tr>
<tr>
<td>Cabrio*, Headline*</td>
<td>pyraclostrobin</td>
<td>high</td>
<td>11</td>
</tr>
<tr>
<td>copper (several)</td>
<td>copper</td>
<td>none-low</td>
<td>M</td>
</tr>
<tr>
<td>Curzate*</td>
<td>cymoxanil</td>
<td>medium-high</td>
<td>27</td>
</tr>
<tr>
<td>Dithane*, Manzate*, Penncozeb*</td>
<td>mancozeb/maneb</td>
<td>none-low</td>
<td>M</td>
</tr>
<tr>
<td>Endura*</td>
<td>boscalid</td>
<td>medium</td>
<td>7</td>
</tr>
<tr>
<td>Flint*, Gem*</td>
<td>trifloxystrobin</td>
<td>high</td>
<td>11</td>
</tr>
<tr>
<td>Fontelis*</td>
<td>penthiopyrad</td>
<td>medium-high</td>
<td>7</td>
</tr>
<tr>
<td>Forum*</td>
<td>dimethomorph</td>
<td>medium-high</td>
<td>40</td>
</tr>
<tr>
<td>Gavel*</td>
<td>mancozeb (M) + zoxamide (22)</td>
<td>low-medium</td>
<td>M, 22</td>
</tr>
<tr>
<td>Inspire Super*</td>
<td>cyprodinil (9) + difenoconazole (3)</td>
<td>medium</td>
<td>9, 3</td>
</tr>
<tr>
<td>Kumulus DF*, Microthiol*, Thiolux Jet*</td>
<td>sulfur</td>
<td>none-low</td>
<td>M</td>
</tr>
<tr>
<td>Luna Experience*</td>
<td>fluopyram (7) + tebuconazole (3)</td>
<td>medium</td>
<td>7, 3</td>
</tr>
<tr>
<td>Luna Sensation*</td>
<td>fluopyram (7) + trifloxystrobin (11)</td>
<td>medium</td>
<td>7, 11</td>
</tr>
<tr>
<td>Luna Tranquility*</td>
<td>fluopyram (7) + pyrimethanil (9)</td>
<td>medium</td>
<td>7, 9</td>
</tr>
<tr>
<td>Merivon*, Priaxor*</td>
<td>fluxapyroxad (11) + pyraclostrobin (7)</td>
<td>Medium-high</td>
<td>7, 11</td>
</tr>
<tr>
<td>Monsoon*, Onset*, Toledo*, Vibe*</td>
<td>tebuconazole</td>
<td>medium</td>
<td>3</td>
</tr>
<tr>
<td>Omega*</td>
<td>fluazinam</td>
<td>low</td>
<td>29</td>
</tr>
<tr>
<td>Orondis Opti*</td>
<td>oxathiapiprolin (U15) + chlorothalonil (M)</td>
<td>medium-high</td>
<td>U15, M</td>
</tr>
<tr>
<td>Orondis Ridomil Gold SL*</td>
<td>oxathiapiprolin (U15) + mfenoxam (4)</td>
<td>medium-high</td>
<td>U15, 4</td>
</tr>
<tr>
<td>Orondis Ultra*</td>
<td>oxathiapiprolin (U15) + mandipropamid (40)</td>
<td>medium-high</td>
<td>U15, 40</td>
</tr>
<tr>
<td>Presidio*</td>
<td>fluopicolide</td>
<td>medium-high</td>
<td>43</td>
</tr>
<tr>
<td>Previcur Flex*</td>
<td>propamocarb</td>
<td>low-medium</td>
<td>28</td>
</tr>
<tr>
<td>Pristine*</td>
<td>boscalid (7) + pyraclostrobin (11)</td>
<td>medium-high</td>
<td>7, 11</td>
</tr>
<tr>
<td>Procure*</td>
<td>triflumizole</td>
<td>medium</td>
<td>3</td>
</tr>
<tr>
<td>Quadris*, Satori*</td>
<td>azoxystrobin</td>
<td>high</td>
<td>11</td>
</tr>
<tr>
<td>Quadris Top*</td>
<td>azoxystrobin (11) + difenoconazole (3)</td>
<td>medium-high</td>
<td>11, 3</td>
</tr>
<tr>
<td>Quintec*</td>
<td>quinoxylen</td>
<td>medium</td>
<td>13</td>
</tr>
<tr>
<td>Rally*</td>
<td>myclobutanil</td>
<td>medium</td>
<td>3</td>
</tr>
<tr>
<td>Ranman*</td>
<td>cyzofamid</td>
<td>medium-high</td>
<td>21</td>
</tr>
<tr>
<td>Reason*</td>
<td>fenamidone</td>
<td>high</td>
<td>11</td>
</tr>
<tr>
<td>Revus*</td>
<td>mandipropamid</td>
<td>medium-high</td>
<td>40</td>
</tr>
<tr>
<td>Revus Top*</td>
<td>mandipropamid + difenoconazole</td>
<td>low-medium</td>
<td>40</td>
</tr>
<tr>
<td>Ridomil*</td>
<td>mfenoxam</td>
<td>high</td>
<td>4</td>
</tr>
<tr>
<td>Rovral*</td>
<td>iprodione</td>
<td>medium</td>
<td>2</td>
</tr>
<tr>
<td>Scala*</td>
<td>pyrimethanil</td>
<td>medium</td>
<td>9</td>
</tr>
<tr>
<td>Switch*</td>
<td>cyprodinil (9) + fludioxonil (12)</td>
<td>low-medium</td>
<td>9, 12</td>
</tr>
<tr>
<td>Tanos*</td>
<td>cymoxanil (27) + famoxadone (11)</td>
<td>medium</td>
<td>27, 11</td>
</tr>
<tr>
<td>Tilt*</td>
<td>propiconazole</td>
<td>medium</td>
<td>3</td>
</tr>
<tr>
<td>Tossin M*</td>
<td>thiophanate-methyl</td>
<td>high</td>
<td>1</td>
</tr>
<tr>
<td>Torino*</td>
<td>cyflufenamid</td>
<td>low moderate</td>
<td>U6</td>
</tr>
<tr>
<td>Zampro*</td>
<td>ametocridin/ dimethomorph</td>
<td>medium</td>
<td>45, 40</td>
</tr>
<tr>
<td>Zing*</td>
<td>chlorothalonil (M), zoxamide (22)</td>
<td>low-medium</td>
<td>M, 22</td>
</tr>
<tr>
<td>Ziram*</td>
<td>ziram</td>
<td>none-low</td>
<td>M</td>
</tr>
</tbody>
</table>

1MOA=mode of action, or FRAC code.
2Fungicides with a numbered MOA code have very specific activity sites and may cause resistance to develop in fungi. These fungicides should be alternated with fungicides with different MOA codes. Read product labels to determine resistance management strategies.
3NA=not available.
4M=multi-site activity. Fungicides with mode of action code M are contact fungicides. It is not necessary to alternate these fungicides for resistance management.
Disease Forecasting Systems

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, 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).

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 or (800) 939-1604. Interested growers can contact Dan Egel at (812) 886-0198 or egel@purdue.edu.

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

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.

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

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.

Slugs and snails prefer moist soils and plenty of organic matter.
### Table 30: 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

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>armyworm</td>
<td>Mythimna (Pseudaelia) unipuncta</td>
<td>Lepidoptera</td>
</tr>
<tr>
<td>asparagus aphid</td>
<td>Brachycorynella asparagi</td>
<td>Hemiptera</td>
</tr>
<tr>
<td>asparagus beetle</td>
<td>Crioceris asparagi</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>asparagus miner</td>
<td>Ophioniya simplex</td>
<td>Diptera</td>
</tr>
<tr>
<td>aster leafhopper</td>
<td>Macrosteles quadrilineatus</td>
<td>Hemiptera</td>
</tr>
<tr>
<td>bandedwinged whitefly</td>
<td>Triauleurodes abutiloneus</td>
<td>Hemiptera</td>
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<tr>
<td>bean aphid</td>
<td>Aphis fabae</td>
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<tr>
<td>bean seed maggot</td>
<td>Delia florilega</td>
<td>Diptera</td>
</tr>
<tr>
<td>bean armyworm</td>
<td>Spodoptera exigua</td>
<td>Lepidoptera</td>
</tr>
<tr>
<td>black cutworm</td>
<td>Acroris ipsilon</td>
<td>Lepidoptera</td>
</tr>
<tr>
<td>brown marmoretated stink bug</td>
<td>Halyomorpha halys</td>
<td>Hemiptera</td>
</tr>
<tr>
<td>brown stink bug</td>
<td>Euschistus servus</td>
<td>Hemiptera</td>
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<tr>
<td>cabbage aphid</td>
<td>Brevicoryne brassicae</td>
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<tr>
<td>cabbage looper</td>
<td>Trichoplusia ni</td>
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<tr>
<td>cabbage maggot</td>
<td>Delia radicum</td>
<td>Diptera</td>
</tr>
<tr>
<td>carrot weevil</td>
<td>Listronotus oregonensis</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>celeri leaflet</td>
<td>Udea rubigalis</td>
<td>Lepidoptera</td>
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<tr>
<td>Colorado potato beetle</td>
<td>Leptinotarsa decemlineata</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>corn earworm</td>
<td>Helicoverpa zea</td>
<td>Lepidoptera</td>
</tr>
<tr>
<td>corn flea beetle</td>
<td>Chaetocnema pulicaria</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>corn leaf aphid</td>
<td>Rhopalosiphum maidis</td>
<td>Hemiptera</td>
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<tr>
<td>cross-striped cabbage worm</td>
<td>Evergestis rimosalis</td>
<td>Lepidoptera</td>
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<tr>
<td>crucifer flea beetle</td>
<td>Phyllotreta cruciferae</td>
<td>Coleoptera</td>
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<tr>
<td>diamondback moth</td>
<td>Plautia xylostella</td>
<td>Lepidoptera</td>
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<tr>
<td>eastern field worm</td>
<td>Limonius agus</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>eggplant flea beetle</td>
<td>Epitrix fuscula</td>
<td>Coleoptera</td>
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<tr>
<td>European corn borer</td>
<td>Ostrinia nubilalis</td>
<td>Lepidoptera</td>
</tr>
<tr>
<td>fall armyworm</td>
<td>Spodoptera frugiperda</td>
<td>Lepidoptera</td>
</tr>
<tr>
<td>fall thrips</td>
<td>Frankliniella tritici</td>
<td>Thysanoptera</td>
</tr>
<tr>
<td>garden webworm</td>
<td>Achara rantalis</td>
<td>Lepidoptera</td>
</tr>
<tr>
<td>golden tortoise beetle</td>
<td>Charidotella (Metrima) sexpunctata bicol</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>green cloverworm</td>
<td>Hypena (Platyhnepa) scabra</td>
<td>Lepidoptera</td>
</tr>
<tr>
<td>green peach aphid</td>
<td>Myzus persicae</td>
<td>Hemiptera</td>
</tr>
<tr>
<td>green stink bug</td>
<td>Acerosternum hilarae</td>
<td>Hemiptera</td>
</tr>
<tr>
<td>harlequin bug</td>
<td>Murycantia histrionica</td>
<td>Hemiptera</td>
</tr>
<tr>
<td>horseradish flea beetle</td>
<td>Phyllotreta armoraciae</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>imported cabbage worm</td>
<td>Pieris rapae</td>
<td>Lepidoptera</td>
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<tr>
<td>melon aphid/cotton aphid</td>
<td>Aphis gossypii</td>
<td>Hemiptera</td>
</tr>
<tr>
<td>Mexican bean beetle</td>
<td>Epilachna varivestis</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>northern corn rootworm</td>
<td>Diabrotica barberi</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>one-spotted stink bug</td>
<td>Euschistus variolarius</td>
<td>Hemiptera</td>
</tr>
<tr>
<td>onion maggot</td>
<td>Delia antiqua</td>
<td>Diptera</td>
</tr>
<tr>
<td>onion thrips</td>
<td>Thrips tabaci</td>
<td>Thysanoptera</td>
</tr>
<tr>
<td>palestriped flea beetle</td>
<td>Systena blanda</td>
<td>Coleoptera</td>
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<tr>
<td>pea aphid</td>
<td>Acrystaphion pisum</td>
<td>Hemiptera</td>
</tr>
<tr>
<td>potato aphid</td>
<td>Macrosiphum euphorbiae</td>
<td>Hemiptera</td>
</tr>
<tr>
<td>potato flea beetle</td>
<td>Epitrix cucumeris</td>
<td>Coleoptera</td>
</tr>
<tr>
<td>potato leafhopper</td>
<td>Empoasca fabae</td>
<td>Hemiptera</td>
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</table>

#### Weeds

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>barnyardgrass</td>
<td>Echinochloa crus-galli</td>
<td>Poaceae</td>
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<tr>
<td>black nightshade</td>
<td>Solanum nigrum</td>
<td>Solanaceae</td>
</tr>
<tr>
<td>common lambquarters</td>
<td>Chenopodium album</td>
<td>Chenopodiaceae</td>
</tr>
<tr>
<td>common purslane</td>
<td>Portula oleracea</td>
<td>Portulacaceae</td>
</tr>
<tr>
<td>common ragweed</td>
<td>Ambrosia artemisiafisil</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>common waterhemp</td>
<td>Amaranthus rudis</td>
<td>Amaranthaceae</td>
</tr>
<tr>
<td>crabgrass</td>
<td>Digitaria sanguinalis</td>
<td>Poaceae</td>
</tr>
<tr>
<td>eastern black nightshade</td>
<td>Solanum ptynanthem</td>
<td>Solanaceae</td>
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<tr>
<td>entireleaf morningglory</td>
<td>Ipomoea hederacea</td>
<td>Convulucaceae</td>
</tr>
<tr>
<td>fall panicum</td>
<td>Panicum dichotomiflorum</td>
<td>Poaceae</td>
</tr>
<tr>
<td>giant foxtail</td>
<td>Setaria faberi</td>
<td>Poaceae</td>
</tr>
<tr>
<td>giant ragweed</td>
<td>Ambrosia trifida L.</td>
<td>Asteraceae</td>
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<tr>
<td>goosegrass</td>
<td>Eleusine indica</td>
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<td>green foxtail</td>
<td>Setaria viridis</td>
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<td>hairy galinsoga</td>
<td>Galinsoga quadriradiata</td>
<td>Asteraceae</td>
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<tr>
<td>ivyleaf morningglory</td>
<td>Ipomoea hederacea</td>
<td>Convulucaceae</td>
</tr>
<tr>
<td>jimsonweed</td>
<td>Datura stramonium</td>
<td>Solanaceae</td>
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### Weeds

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>lady's thumb</td>
<td>Polygonum persicaria</td>
<td>Polygonaceae</td>
</tr>
<tr>
<td>Pennsylvanian smartweed</td>
<td>Polygonum pensylvanicum</td>
<td>Polygonaceae</td>
</tr>
<tr>
<td>redroot pigweed</td>
<td>Amaranthus retroflexus</td>
<td>Amaranthaceae</td>
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<tr>
<td>smooth pigweed</td>
<td>Amaranthus hybridus</td>
<td>Amaranthaceae</td>
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<td>tall morningglory</td>
<td>Ipomoea purpurea</td>
<td>Convolvulaceae</td>
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<tr>
<td>velvetleaf</td>
<td>Abutilon theophrasti</td>
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<tr>
<td>yellow foxtail</td>
<td>Setaria pulmona</td>
<td>Poaceae</td>
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<tr>
<td>yellow nutesedge</td>
<td>Cyperus esculentus</td>
<td>Cyperaceae</td>
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### Diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen</th>
<th>Host Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>black leg of cole crops</td>
<td>Phoma lingam</td>
<td>cole crops</td>
</tr>
<tr>
<td>black rot of sweet potato</td>
<td>Ceratocystis fimbriata</td>
<td>sweet potato</td>
</tr>
<tr>
<td>black rot of cole crops</td>
<td>Xanthomonas campestris pv. campestris</td>
<td>cole crops</td>
</tr>
<tr>
<td>blackleg</td>
<td>Erwinia carotovora subsp. atrosepta</td>
<td>potato</td>
</tr>
<tr>
<td>Botrytis leaf blight</td>
<td>Botrytis squamosa</td>
<td>onion</td>
</tr>
<tr>
<td>Botrytis neck rot</td>
<td>Botrytis allii</td>
<td>onion</td>
</tr>
<tr>
<td>Botrytis gray mold</td>
<td>Botrytis cinerea</td>
<td>lettuce, spinach, legumes</td>
</tr>
<tr>
<td>bottom rot/damping-off</td>
<td>Rhizoctonia solani</td>
<td>lettuce</td>
</tr>
<tr>
<td>buckeye rot</td>
<td>Phytophthora spp.</td>
<td>tomato</td>
</tr>
<tr>
<td>canker/black scurf</td>
<td>Rhizoctonia solani</td>
<td>potato</td>
</tr>
<tr>
<td>cavity spot</td>
<td>Pythium violae, Pythium spp.</td>
<td>carrot</td>
</tr>
<tr>
<td>Cercospora leaf spot of beet</td>
<td>Cercospora beticola</td>
<td>beet</td>
</tr>
<tr>
<td>Cercospora leaf spot of carrot</td>
<td>Cercospora carotae</td>
<td>carrot</td>
</tr>
<tr>
<td>Cercospora leaf spot of parsnip, turnip</td>
<td>Cercospora spp.</td>
<td>parsnip, turnip</td>
</tr>
<tr>
<td>chlorotic dwarf</td>
<td>Maize chlorotic dwarf virus</td>
<td>sweet corn</td>
</tr>
<tr>
<td>club root</td>
<td>Plasmodiophora brassicola</td>
<td>cole crops</td>
</tr>
<tr>
<td>common bacterial blight</td>
<td>Xanthomonas campestris pv. phaseoli</td>
<td>legumes</td>
</tr>
<tr>
<td>common rust</td>
<td>Puccinia sorghi</td>
<td>sweet corn</td>
</tr>
<tr>
<td>crater rot</td>
<td>Rhizoctonia solani</td>
<td>celery</td>
</tr>
<tr>
<td>cucumber mosaic</td>
<td>Cucumber mosaic virus</td>
<td>cucurbits, pepper, peper, legumes</td>
</tr>
<tr>
<td>cyst nematode disease</td>
<td>Heterodera glycines</td>
<td>legumes</td>
</tr>
<tr>
<td>damping-off</td>
<td>Pythium spp.</td>
<td>cilantro, dill, legumes, lettuce, onion, parsley, parsnip, spinach, and other vegetables</td>
</tr>
<tr>
<td>damping-off (greenhouse)</td>
<td>Pythium spp.</td>
<td>celery</td>
</tr>
<tr>
<td>downy mildew of basil</td>
<td>Peronospora belbahrii</td>
<td>basil</td>
</tr>
<tr>
<td>downy mildew of cole crops</td>
<td>Hyaloperonospora parasitica</td>
<td>cole crops</td>
</tr>
<tr>
<td>downy mildew of cucurbits</td>
<td>Pseudoperonospora cubensis</td>
<td>cucurbits</td>
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<tr>
<td>downy mildew of dill/parsnip</td>
<td>Peronospora umbellifarum</td>
<td>dill, parsnip</td>
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<tr>
<td>downy mildew of garlic/onion</td>
<td>Peronospora destructor</td>
<td>garlic, onion</td>
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<td>downy mildew of lettuce</td>
<td>Bremia lactucae</td>
<td>lettuce</td>
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<td>downy mildew of spinach</td>
<td>Peronospora farinosa</td>
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<td>downy mildew of turnip</td>
<td>Bremia parasitica</td>
<td>turnip</td>
</tr>
<tr>
<td>drop (Sclerotinia rot)</td>
<td>Sclerotinia sclerotiorum</td>
<td>lettuce</td>
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<tr>
<td>dry rot</td>
<td>Fusarium solani</td>
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</tr>
<tr>
<td>dwarf mosaic</td>
<td>Maize dwarf mosaic virus</td>
<td>sweet corn</td>
</tr>
<tr>
<td>Diseases</td>
<td>Pathogen</td>
<td>Host Crop</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>early blight of celery</td>
<td>Cercospora apii</td>
<td>celery</td>
</tr>
<tr>
<td>early blight of tomato</td>
<td>Alternaria solani</td>
<td>potato, tomato</td>
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<tr>
<td>foot rot of tomato</td>
<td>Fusarium solani</td>
<td>tomato</td>
</tr>
<tr>
<td>foot rot of sweet potato</td>
<td>Plenodomus destruens</td>
<td>sweet potato</td>
</tr>
<tr>
<td>fruit rot of cucurbits</td>
<td>Fusarium solani f. sp. cucurbitae</td>
<td>cucurbits</td>
</tr>
<tr>
<td>Fusarium crown and root rot</td>
<td>Fusarium oxysporum f. sp. asparagi, F. proliferatum</td>
<td>asparagus</td>
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<td>Fusarium wilt of basil</td>
<td>Fusarium oxysporum f. sp. basilicum</td>
<td>basil</td>
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<td>Fusarium wilt of watermelon</td>
<td>Fusarium oxysporum f. sp. niveum</td>
<td>watermelon</td>
</tr>
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<td>Fusarium wilt of sweet potato</td>
<td>Fusarium oxysporum f. sp. batatas</td>
<td>sweet potato</td>
</tr>
<tr>
<td>Fusarium wilt of tomato</td>
<td>Fusarium oxysporum f. sp. lycopersici</td>
<td>tomato</td>
</tr>
<tr>
<td>Fusarium wilt of legumes</td>
<td>Fusarium oxysporum f. sp. phasolii</td>
<td>legumes</td>
</tr>
<tr>
<td>Fusarium wilt of okra</td>
<td>Fusarium oxysporum f. sp. vaninfectum</td>
<td>okra</td>
</tr>
<tr>
<td>gray leaf spot</td>
<td>Cercospora zeae-maydis</td>
<td>sweet corn</td>
</tr>
<tr>
<td>gummy stem blight/ black rot</td>
<td>Didymella bryoniae</td>
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<td>Phytophthora infestans</td>
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<tr>
<td>leaf mold</td>
<td>Fulvia fulva</td>
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<tr>
<td>lettuce mosaic</td>
<td>Lettuce mosaic virus</td>
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<tr>
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<td>Bipolaris zeicola</td>
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<td>Exserohilum turcicum</td>
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<td>Phytophthora capsici</td>
<td>cucurbits, solanaceous</td>
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<tr>
<td>Phytophthora crown and spear rot</td>
<td>Phytophthora asparagi</td>
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<td>Setophoma terrestris</td>
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<td>Potato virus y</td>
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<td>Erysiphe cichoracearum</td>
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<td>Erysiphe cruciferarum</td>
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<td>Leveillula taurica</td>
<td>pepper, tomato</td>
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<td>Podosphaeria xanthii</td>
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<td>purple blotch</td>
<td>Alternaria porri</td>
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<td>Stemphylium vesicarium</td>
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<td>Rhizoctonia diseases</td>
<td>Rhizoctonia solani</td>
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<td>ring rot</td>
<td>Clavibacter michiganensis subsp. sepedonicus</td>
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<td>Papaya ringspot virus</td>
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<td>Phytophthora spp.</td>
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<td>root knot</td>
<td>Meloidogyne spp.</td>
<td>beet, carrot, cucurbits, potato</td>
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<td>root lesion</td>
<td>Pratylenchus spp.</td>
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<td>Puccinia asparagi</td>
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<td>rust of legumes</td>
<td>Uromyces appendiculatus</td>
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<tr>
<th>Diseases</th>
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<th>Host Crop</th>
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<tr>
<td>scab of cucurbits</td>
<td>Cladosporium cucumerinum</td>
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<td>scab of potato</td>
<td>Streptomyces scabies</td>
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<tr>
<td>scurf</td>
<td>Monilochaetes infuscans</td>
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<td>Septoria blight of parsley</td>
<td>Septoria petroselini</td>
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<td>Septoria leaf blight of tomato</td>
<td>Septoria lycopersici</td>
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<td>Septoria leaf spot of radish</td>
<td>Septoria lycopersici</td>
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<td>Septoria leaf spot of mint</td>
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<td>silver scurf</td>
<td>Helminthosporium solani</td>
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<td>slippery skin</td>
<td>Pseudomonas gladioli pv. allicola</td>
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<td>Urocystis colchici</td>
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<td>Ustilago maydis</td>
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<td>Pseudomonas cepacia</td>
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<td>Sclerotium rolfsii</td>
<td>eggplant, pepper, tomato</td>
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<td>Bipolaris maydis</td>
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<td>Puccinia polysora</td>
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<td>Puccinia menthae</td>
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<td>Erwinia Stewartii</td>
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<td>Verticillium dahliae, Verticillium albo-atrum</td>
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<td>white mold (timber rot)</td>
<td>Sclerotinia sclerotiorum</td>
<td>carrot, cole crops, eggplant, legumes, mint, pepper, potato, tomato</td>
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<td>Albugo candida</td>
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<td>yellows</td>
<td>Fusarium oxysporum spp.</td>
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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. P₂O₅: 25 to 200 pounds per acre. K₂O: 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 P₂O₅ or K₂O is necessary if adequate fertilization was achieved prior to planting.

Disease Control
Fusarium Crown and Root Rot
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.

Recommended Products
Cannonball® as a crown soak at 0.5 oz. per 100 gals. of water. 365-day PHI. Michigan requires a Section 24(c) Special Local Need Label through December 31, 2018. 365-day PHI.

Rust
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.

Recommended Products
Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. 190-day PHI.

Mancozeb products (including Dithane®, Koverall®, Manzate®, and Penncozeb®) are labeled at various rates. See product labels. 180-day PHI.

Monsoon®, or Onset 3.6L®, or Orius 3.6F®, or Tebuzol 3.6F®, or Toledo 3.6F® at 4-6 fl. oz. per acre. 180-day PHI.

Rally 40WSP® or Sonoma 40WSP® at 5 oz. per acre. 180-day PHI.
Phytophthora Crown and Spear Rot
Avoid excessive irrigation. Establish production fields from blemish free crowns obtained from virgin soil or fumigated soil.

Recommended Products
* Ridomil Gold SL® at 1 pt. per acre.
* Ultra Flourish® at 2 pts. per acre. 1-day PHI.

Purple Spot
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 77) for more details. NOTE: Products labeled for rust may be helpful for purple spot control.

Recommended Products
* Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. 190-day PHI.
* Flint® at 3-4 oz. per acre. 180-day PHI.
* Quadris Flowable® at 6-15.5 fl. oz. per acre. 100-day PHI.

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. It is important to avoid damaging crowns when cultivating.

For specific weeds controlled by each herbicide, check Table 25 on page 66.

Preemergence Broadleaves and Grasses

Recommended Products
* Chateau WDG® at 6 oz. per acre. 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. Do not exceed 6 oz. per acre per growing season.
* Diuron products at 0.8-3 lbs. a.i. per acre. Use 80DF formulations at 1-4 lbs. per acre, or 4L formulations at 1.6-3 qts. per acre. Do not apply to young plants during first year. 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. 6-8 weeks residual activity. Do not exceed 6 lbs. per acre per year.
* Dual Magnum 7.62E® at 1.33-2.0 pts. per acre. Apply before asparagus and weeds emerge in spring or after the harvest season. Needs moisture for activation. Do not exceed 1 application per crop. Growers in Michigan must have a 24(c) label. 16-day PHI.
* Prowl H2O® at 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. 14-day PHI.
* Sencor 4F® at 0.5-2 qts. per acre, or Sencor 75DF® at 0.6-2.6 lbs. per acre. Do not apply to young plants during first year. Apply after tillage or chopping fern in the spring and after harvest, if necessary. Use lower rates for split applications. 6-8 weeks residual activity. Do not exceed 2 qts. or 2.6 lbs. per acre per year. 2 sprays necessary for seasonlong sandbur control. 14-day PHI.
* Sinbar 80W® at 0.62-1.5 lbs. per acre. Established crowns or directed seeded plants only. Do not use on sandy soil or on soil with less than 1% organic matter. Apply in spring after cutting fern and prior to spear emergence. For seeded crops apply activated charcoal at 300 lbs. per acre in a 1-inch band over the row before Sinbar® application. Do not plant other crops within 2 years of application. 8-12 weeks residual activity. 5-day PHI.
* Solicam DF® at 2.5-5 lbs. per acre. Do not apply within 12 months of planting. Apply preemergence to soil free of weeds and debris. 14-day PHI.
* Spartan 4F® at 4.5-12 fl. oz. per acre. 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. 14-day PHI.
Spur 3L* at 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. 2-day PHI.

Trifluralin products at 1-1.5 lbs. a.i. per acre. Use 4EC formulations at 1-1.5 qts. per acre. Established plantings only. Apply and incorporate 1-2 inches early in the spring when spears are at least 4 inches below soil surface. Use higher rates on heavier soils. 4-6 weeks residual activity.

**Preemergence Broadleaves**

**Recommended Products**

**Callisto 4L** at 6-7.7 fl. oz. per acre. Apply in spring before spears emerge after mowing, disking, or tilling; after final harvest; or both. Do not exceed 2 applications per year, or 7.7 fl. oz. per acre per year.

**Lorox 50DF** at 2-4 lbs. per acre. Do not use on sand, loamy sand, or soils with less than 1% organic matter. Maximum 4 lbs. or 3 applications per acre per year. 1-day PHI.

**Postemergence Broadleaves and Grasses**

**Recommended Products**

**Glyphosate** products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations that contain 3 lbs. ae/gal. (equivalent to 4 lbs. isopropylamine salt/gal.) at 1-5 qts. per acre; or formulations that contain 4.5 lbs. ae/gal. (equivalent to 5 lbs. potassium salt/gal.) at 0.66-3.3 qts. per acre. Apply to emerged weeds at least 7 days before spears emerge or immediately after the 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. Delayed treatments must be applied as a directed or shielded spray. Direct contact of the spray with asparagus fern may result in serious crop injury.

**Gramoxone Inteon2L** at 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. RUP. 6-day PHI.

**Postemergence Broadleaves**

**Recommended Products**

**Callisto 4L** at 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) will improve emerged weed control and increase crop injury risk in postharvest applications. Do not exceed 2 applications per year, or 7.7 fl. oz. per acre per year.

2,4-D amine at 3-4 pts. per acre. 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 the fern.

**Clarity 4L** at 0.5-1 pt. per acre. Apply at 40-60 gals. 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. 24-hour PHI.

**Lorox 50DF** at 1-3 lbs. per acre and up to 3 applications for established beds. Apply before cutting season or immediately after cutting. For newly planted crowns apply 1-2 lbs. per acre, up to 2 applications when ferns are 6-18 inches tall. Do not use on sand, loamy sand, or soils with less than 1% organic matter. 1-day PHI.

**Savage WSG** at 1.5-2 lbs. per acre. 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 the fern.

**Sandra 75W** at 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. 1-day PHI.

**Postemergence Grasses**

**Recommended Products**

**Clortho** products at 0.068-0.125 lb. a.i. per acre. Use formulations with 0.97 lb. a.i. per gallon at 9-16 fl. oz. per acre. Use formulations with 2 lb. a.i. per gallon at 6-8 fl. oz. per acre. Use 1 qt. COC per 25 gallons of spray solution (1% v/v). Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5 pts. per acre per season. 1-day PHI.

**Fusilade DX 2E** at 8-12 fl. oz. per acre. Include 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gallons 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. 1-day PHI.

**Poast 1.5E** at 1-1.5 pts. per acre, plus 1 qt. COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 5 pts. per acre per season. 1-day PHI.

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This is a reduced-risk pesticide. See page 37 for details.
### Herbicides for Asparagus

<table>
<thead>
<tr>
<th>Product (REI/PHI)</th>
<th>Common Name</th>
<th>Timing and Application Location Relative to Crop</th>
<th>Timing Relative to Weeds</th>
<th>Weed Groups Controlled</th>
<th>OK on Young Plantings?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before spears emerge in spring</td>
<td>After final harvest before fern grows</td>
<td>During harvest period after cutting spears</td>
<td>Postemergence to ferns after harvest</td>
<td>Directed or shielded spray to ferns after harvest</td>
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<tr>
<td>Callisto 4L* (12h/-)</td>
<td>mesotrione</td>
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<td>Chateau* (12h/-)</td>
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<td>Clarity 4L* (24h/1d)</td>
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<tr>
<td>Dual Magnum*</td>
<td>metolachlor</td>
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<td>Gramoxone Inteon 2L* (12h to 24h/6d)</td>
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<td>Roundup*, others (12h/-)</td>
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<td>2,4-D amine</td>
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</tr>
<tr>
<td>Trelan*, others (12h/-)</td>
<td>trifluralin</td>
<td>X</td>
<td>No</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

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1 For effectiveness against specific weeds, see Table 25 on page 66, 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.
Insect Control

Armyworm

Recommended Products
Coragen® at 3.5-5 fl. oz. per acre. Do not exceed more than 4 applications per season. Do not exceed more than 15.4 fl. oz. per season. Minimum interval between treatments is 3 days. 1-day PHI.

Lannate LV® at 1.5-3 pts. per acre. Do not exceed 8 applications per season. Use high rate for white cutworm. 1-day PHI. RUP.

Lorsban 4E® at 2 pts. per acre, or Lorsban 75WG® at 1.33 lbs. per acre. Do not make more than 1 preharvest application. Do not make more than two postharvest applications during the fern stage. 1-day PHI. RUP.

Asparagus Aphids
Treat when less than 5 percent of ferns have aphids present.

Recommended Products
Assail 30SG® at 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. 1-day PHI.

Fulfil® at 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 a total of 16.5 oz. per acre per growing season. 170-day PHI.

Lorsban 4E® at 2 pts. per acre, or Lorsban 75WG® at 1.33 lbs. per acre. Do not make more than one preharvest application. Do not make more than two postharvest applications during the fern stage. 1-day PHI. RUP.

Asparagus Beetles and Cutworms
Treat when insects reach the economic thresholds described below.

Harvest
Asparagus Beetle
5-10% plants infested or 2% of spears with eggs
Cutworms
5% of crowns infested

Fern
Asparagus Beetle
10% defoliation or 50% of plants with larvae

Fall
Cutworms
1 larva per 20 plants

Tarnished Plant Bugs and Japanese Beetle
(Adult Stage)
Treat when less than 5 percent of ferns have aphids present.

Recommended Products
Assail 30SG® at 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. 1-day PHI.

Lannate LV® at 1.5-3 pts. per acre. Do not exceed 8 applications per season. Use high rate for white cutworm. 1-day PHI. RUP.

Lorsban 4E® at 2 pts. per acre, or Lorsban 75WG® at 1.33 lbs. per acre. Do not make more than 1 preharvest application. Broadcast with ground equipment. 1-day PHI. RUP.

Malathion 57EC® at 1.5-2 pts. per acre. Asparagus beetles only. 1-day PHI.

Pounce 25WP® at 3.2-6.4 lbs. per acre. Do not exceed 0.4 lb. a.i. per season. 1-day PHI. RUP.

Sevin XLR PLUS® (4F) at 1 qt. per acre, or Sevin 5B® at 20 lbs. per acre. Do not treat more than once every 3 days. Bait for cutworms only. 1-day PHI.

For control on seedlings and fern growth after harvest is over (use lower rates for seedlings):
Dimethoate 400® or Dimethoate 4E® at 1 pt. per acre. Asparagus beetles only. Apply after harvest. Do not exceed 1 lb. a.i. per acre per season. 180-day PHI

Entrust® at 4-6 fl. oz. per acre. Asparagus beetles only. Do not exceed 18 fl. oz. per acre per season. 60-day PHI.

Radiant SC® at 4-8 fl. oz. per acre. Asparagus beetles only. Do not exceed 24 fl. oz. per acre per season. 60-day PHI.

Sevin XLR PLUS® (4F) at 2-4 qts. per acre. Do not treat more than once every 3 days. Do not exceed 5 applications per year to spears and ferns combined.

This is a reduced-risk pesticide. See page 37 for details.
May be acceptable for use in certified organic production. Check with your certifier before use.
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

Includes Chinese cabbage (Napa cabbage and bok choy), daikon radish.

Chinese Cabbage (Napa cabbage and bok choy): Chinese cabbage has been grown in Asia since the 5th century. 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 broadleafed, compact-heading varieties of which there are two forms, Chihili and Che-foo.

Chihili forms of Napa cabbage form a cylindrical head 18 inches long and 6 inches in diameter, with an erect, upright growing habit. Some of the 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 nonheading form of Chinese cabbage, with several thick white leafstalks. The smooth, glossy, dark green leaf blades form a celery-like cluster. There aren’t as many varieties as there are of the Napa type: two are Canton Choice, and Long White Petiole.

Chinese cabbage is a cool-season annual vegetable. It grows best with short days and moderate to cool temperatures (60-70°F). Their cultural requirements are similar to those of cabbage and lettuce. Chinese cabbage is fairly quick in maturing. It varies from 40 days from sowing to harvest for some cultivars, to 75 days for the longer maturing ones. Space Napa cabbage 18 inches apart and bok choy types 8-12 inches apart and 24 inches between rows.

Daikon Radish (Raphanus sativus, var. longipinnatus, also called Chinese radish): This root crop is very closely related to the common radish. The main planting times are spring and fall, but some varieties can be planted almost year-round. Bolting (premature seedstalk) can
be a problem. Plant the seeds ¾ inch deep in April for a spring crop or in July for a fall crop. Plant spacing should be 4-6 inches between plants and 3 feet between rows. To compensate for large root size, plant daikon radishes in high raised beds that are amended with organic matter, such as compost. At each cultivation, work the soil higher and higher around the root as it grows. Most daikon radishes reach their useable size in 60-70 days.

**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 actuangulara*, 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** (*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**


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.

\[ P_2O_5: \] 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 \( P_2O_5 \) per acre per year should be sufficient.

\[ K_2O: \] 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 \( K_2O \) 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 \( P_2O_5 \) and up to 40 pounds of \( K_2O \) 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.

Disease Control

Anthracnose
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.
**Recommended Products**

**Cabrio®** at 12-16 oz. per acre. 0-day PHI.

**Merivon Xemium Brand Fungicide®** at 4-11 fl. oz. per acre. 1-day PHI.

**Pristine®** at 10-15 oz. per acre. 0-day PHI.

**Bacterial Leaf Blight**

Symptoms include leaf blight and extensive leaf death that requires additional trimming at harvest, resulting in yield loss. May be seedborne.

**Recommended Products**

**Cabrio®** at 12-16 oz. per acre. 0-day PHI.

**Merivon Xemium Brand Fungicide®** at 4-11 fl. oz. per acre. 1-day PHI.

**Pristine®** at 10-15 oz. per acre. 0-day PHI.

**Recommended Products**

**Catamaran®** at 4-5 pts. per acre. 0-day PHI.

Several formulations of **copper** products (Badge®, Champ®, Curpofix®, Copper Count-N®, Kocide®, Nu-Cop®) are labeled for use and may slow spread of bacterial leaf blight. See label for directions.

**Crater Rot**

Apply as a basal spray after each cultivation.

**Recommended Products**

**Catamaran®** at 4-5 pts. per acre. 0-day PHI.

**chlorothalonil** products (including Bravo® and Equus®) are labeled at various rates. See product labels.

**Quadris Flowable®** at 0.4-0.8 fl. oz. per 1,000 row feet. 0-day PHI.

**Quadris Opti®** at 2.4-3.7 pts. per acre. 7-day PHI.

**Early Blight, Late Blight**

Early blight symptoms include small, yellow spots that rapidly enlarge to tan or gray lesions. All aboveground tissues of celery can become infected resulting in losses of 50% or more when blighted stalks or leaves have to be removed at harvest. Symptoms of Septoria late 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.

**Recommended Products**

**Cabrio®** at 12-16 oz. per acre. 0-day PHI.

**Catamaran®** at 4-5 pts. per acre. 7-day PHI.

Several **chlorothalonil** formulations are labeled and may lessen the severity of crater rot. See labels for directions.

**Damping-off**

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.

**Recommended Products**

**Ridomil Gold® SL** at 1-2 pts. per acre, or **Ridomil Gold® GR** at 20-40 lbs. per acre, or **Ultra Flourish®** at 2-4 pts. per acre. Apply preplant for greenhouse production.

**Weed Control**

**Burndown or Directed/Shielded**

**Recommended Products**

**Roundup 4L®** at 2-3 qts. per acre. Apply to emerged perennials before planting in the spring or after harvest in the fall.

**Preemergence Broadleaves and Grasses**

**Recommended Products**

**Caparol 4L®** at 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.

**Chateau 51WDG®** at 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.
Dual Magnum® at 1-2 pts. per acre. Apply before or immediately after transplanting will control annual grass and small-seeded broadleaf weeds. Use high rate on muck soils. Follow with 0.25 inch water within 7 days. For yellow nutsedge, growers in Michigan should be in possession of the 24(c) label. 62-day PHI.

Lorox 50DF® at 1.5-2 lbs. per acre. Apply after transplanting 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.

**Postemergence Grasses**

**Recommended Products**

Poast 1.5E® at 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. 30-day PHI.

Select Max 0.97E® at 9-16 fl. oz. per acre. Apply to actively growing grasses. Do not exceed 64 fl. oz. per acre per year. Include 0.25% NIS v/v of spray solution. 30-day PHI.

**Insect Control**

**Aphids, Leafminers, Mites**

Treat at the following thresholds:

**Aphids**

When more than 3 percent of plants are infested.

or

There are more than six aphids per 100 sweeps.

Over-treatment with pyrethroids may cause increased aphid problems.

**Leafminers**

Apply as soon as visible mines appear and repeat every 7 days as needed.

**Recommended Products**

Actara® at 1.5-3 oz. per acre. Aphids only. 7-day PHI.

Admire PRO® at 4.4-10.5 fl. oz. per acre. 45-day PHI.

Agri-Mek® (0.15 EC) at 8-16 fl. oz. per acre, or Agri-Mek® (SC) at 1.75-3.5 fl. oz. per acre. Leafminers and mites only. Use with a nonionic surfactant. 7-day PHI. RUP.

Ambush 25W® at 6.4-12.8 oz. per acre. Leafminers only. 1-day PHI. RUP.

Assail® (30SG) at 2-4 oz. per acre, or Assail® (70WP) at 0.8-1.7 oz. per acre. Aphids only. 7-day PHI.

Belay 50WDG® at 1.6-2.1 oz. per acre. Aphids only. 7-day PHI.

Beleaf 50SC® at 2-2.8 oz. per acre. Aphids only. 0-day PHI.

Brigade® (WSB) at 5.3-16 oz. per acre. Aphids only. 7-day PHI. RUP.

Coragen® at 5.0-7.5 fl. oz. per acre. Leafminers only. Can be applied as a soil treatment or foliar treatment. See label for application methods. 1-day PHI.

Dibrom 8 Emulsive® at 1-1.5 pts. per acre. 1-day PHI. RUP.

Dimethoate 4EC® at 1 pt. per acre. Leafminers and mites only. 7-day PHI.

Durivo® at 10-13 fl. oz. per acre as a soil treatment. 30-day PHI.

Entrust® at 2-3 oz. per acre, or Entrust® (2SC) at 6-10 fl. oz. per acre. Leafminers only. 1-day PHI.

Exirel® at 13.5-20.5 oz. per acre.

Fulfill® at 2.75 oz. per acre. Aphids only. May require 5-7 days for aphid mortality. 0-day PHI.

Various Malathion® formulations are available. Aphids and mites only. See labels for rates. 7-day PHI.

Movento® at 4-5 fl. oz. per acre. Aphids only. Must be tank mixed with penetrating adjuvant. 3-day PHI.

Mustang Maxx® at 2.24-4 oz. per acre. Aphids only. 1-day PHI. RUP.

Oberon 2SC® at 7-8.5 fl. oz. per acre. Mites only. Michigan growers must possess a special SLN label. 7-day PHI.

Orthene 97® at 8-16 oz. per acre. Aphids only. 21-day PHI.

Platinum® at 5-11 fl. oz. per acre, or Platinum 75SG® at 1.66-3.67 oz. per acre. Leafminers only. 30-day PHI.

Pounce 25WP® at 6.4-12.8 oz. per acre. 1-day PHI. RUP.

Pyrenone® at 1-12 fl. oz. per acre. 0-day PHI.

Radiant SC® at 6-10 fl. oz. per acre. Leafminers only. 1-day PHI.

This is a reduced-risk pesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.
Scorpion 35SL® at 2-5.25 fl. oz. per acre. Leafminers only. 7-day PHI.

Sivanto® at 10.5-12.0 fl. oz. per acre. Can be applied as a soil treatment or foliar treatment. See label for application methods. Aphids only.

Torac® at 17-21 oz. per acre. Aphids only. Do not exceed 2 applications per crop per year.

Trigard® at 17-21 oz. per acre. Aphids only.

Venom® at 1-3 oz. per acre. Leafminers only. 7-day PHI.

Verimark® at 6.75-13.5 oz. per acre as a soil treatment. See label for application methods. 0-day PHI.

Armyworm, Corn Earworm, Cutworm, Loopers

Treat at the following thresholds:

Armyworm and cutworm:

Apply preventive treatments within 4 weeks of harvest.

Loopers:

Apply if needed- protect plants within 4 weeks of harvest.

Recommended Products

Ambush 25W® at 6.4-12.8 oz. per acre. Not for cutworms. 1-day PHI. RUP.

Avaunt® at 3.5 oz. per acre. Armyworm and loopers only. 3-day PHI.

Several Bacillus thuringiensis products (Agree®, Bio-bit®, Dipel®, Javelin®, Xentari®) are available. Not for corn earworm. Follow label directions for rates. 0-day PHI.

Baythroid XL® at the following rates:

Armyworm: 2.4-3.2 fl. oz. per acre.
Cutworm: 0.8-1.6 fl. oz. per acre.
Loopers: 1.6-2.4 fl. oz. per acre.
0-day PHI. RUP.

Brigade® (WSB) at 5.3-16.0 oz. per acre. Not for corn earworm. 7-day PHI. RUP.

Confirm 2F® at 6-8 fl. oz. per acre. Armyworm and loopers only. 7-day PHI.

Coragen® at 3.5-5.0 fl. oz. per acre. Armyworm and loopers only. Can be applied as a foliar spray or soil treatment. See label for application methods. Must wait at least 3 days between foliar applications. Do not exceed 15.4 fl. oz. per acre per season. 1-day PHI.

Dibrom 8 Emulsive® at 1.0-1.5 pts. per acre. Armyworm and loopers only. 1-day PHI. RUP.

Durivo® at 10-13 fl. oz. per acre as a soil treatment. Armyworm and loopers only. 30-day PHI.

Entrust® at the following rates:

Armyworm: 1.25-2.5 oz. per acre.
Loopers: 1-2 oz. per acre
1-day PHI.

Entrust® (2SC) at the following rates:

Armyworm: 4-8 fl. oz. per acre.
Loopers: 3-6 fl. oz. per acre.
1-day PHI.

Exirel® at 7.0-13.5 oz. per acre. Armyworm and corn earworm only.

Intrepid 2F® for armyworm and loopers only at the following rates:

Early-season applications to young, small crops: 4-8 fl. oz. per acre.
Mid- to late-season applications: 8-10 fl. oz. per acre.
1-day PHI.

Lannate SP® at the following rates:

Armyworm: 0.25-1 lb. per acre.
Cutworm: 0.5 lb. per acre.
Loopers: 1 lb. per acre.
7-day PHI. RUP.

Larvin 3.2® at 16-30 fl. oz. per acre. Armyworm and loopers only. 14-day PHI. RUP.

Mustang Maxx® at the following rates:

Armyworm and loopers: 3.2-4 oz. per acre.
Cutworm: 2.24-4 oz. per acre.
1-day PHI. RUP.

Orthene 97® at 16 oz. per acre. Armyworm and loopers only. 21-day PHI.

Proclaim® at the following rates:

Armyworm: 2.4-4.8 oz. per acre. only. 7-day PHI.
Loopers: 3.2-4.8 oz. per acre. only.
RUP.
Pyrenone® at 1-12 fl. oz. per acre. Not for corn earworm. 0-day PHI.

Radiant SC® at 5-10 fl. oz. per acre. Armyworm and loopers only. 1-day PHI.

Various Sevin® formulations are available. Armyworm only. See labels for rates. 14 day PHI.

Torac® at 21 oz. per acre. Suppression only. Do not exceed 2 applications per crop per year.

Verimark® at 6.75-13.5 oz. per acre as a soil treatment. Loopers only. 0-day PHI.

**Carrot Weevil**

**Recommended Products**

Pyrenone® at the following rates:

- **Larvae**: 1-12 fl. oz. per acre. Apply as a directed spray. Start when eggs or larvae are first seen and repeat in 2 to 3 weeks. 0-day PHI.

- **Adults**: 1-12 fl. oz. per acre. Apply when adults are first caught in traps or eggs are first seen. No materials are labeled specifically for this area, however, this will give some control. 0-day PHI.

Vydate L® at 4 pts. per acre. Larvae only. Apply as a directed spray. Start when eggs or larvae are first seen and repeat in 2 to 3 weeks. 21-day PHI. RUP.

**Diamondback Moth**

**Recommended Products**

Exirel® at 7.0-13.5 oz. per acre.

Movento® at 4.0-5.0 fl. oz. per acre. Must be tank-mixed with adjuvant with spreading and penetrating properties. 1-day PHI.

**Leafhoppers**

Treat when there are more than 14 leafhoppers per 100 sweeps.

Repeat as needed, depending on number of leafhoppers.

**Recommended Products**

Actara® at 1.5-3.0 oz. per acre. Over-treatment with permethrin may increase aphid problems. 7-day PHI.

Admire PRO® at 4.4-10.5 fl. oz. per acre as a soil treatment. 45-day PHI.

Ambush 25W® at 6.4-12.8 oz. per acre. Over-treatment with permethrin may increase aphid problems. 1-day PHI. RUP.

Baythroid XL® at 2.4-3.2 fl. oz. per acre. Over-treatment with permethrin may increase aphid problems. 0-day PHI. RUP.

Belay® (50WDG) at the following rates:

- **Soil treatment**: 4.8-6.4 oz. per acre.
- **Foliar treatment**: 1.6-2.1 oz. per acre.

Brigade® (WSB) at 5.3-16 oz. 7-day PHI. RUP.

Durivo® at 10-13 fl. oz. per acre. 30-day PHI.

Lannate SP® at 0.5-1 lb. per acre. 7-day PHI. RUP.

Nuprid 2F® at 10-24 fl. oz. per acre as a soil treatment. 45-day PHI.

Mustang Maxx® at 2.24-4 oz. per acre. Over-treatment with permethrin may increase aphid problems. 1-day PHI. RUP.

Platinum® at 5-11 fl. oz. per acre as a soil treatment, or Platinum 75SG® at 1.66-3.67 oz. per acre as a soil treatment. 30-day PHI.

Pyrenone® at 1-12 fl. oz. per acre. 0-day PHI.

Various Sevin® formulations are available. See labels for rates. 14-day PHI.

Scorpion 35SL® at 2-5.25 fl. oz. per acre. 7-day PHI.

Sivanto® at 7.0-10.5 fl. oz. per acre as a soil treatment. See label for application methods.

Torac® at 14-21 oz. per acre. Do not exceed 2 applications per crop per year.

Venom® at the following rates:

- **Soil treatment**: 5-6 oz. per acre. 21-day PHI.
- **Foliar treatment**: 1-3 oz. per acre. 7-day PHI.

See label for application methods.

**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. The following nematicides are suitable for control of root-knot, pin, needle, and lesion nematodes in celery production.

This is a reduced-risk pesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.


**Recommended Products**

**Telone II**® for fall soil fumigation (broadcast) at the following rates:

- **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 the fumigant to a soil depth of 8 inches and lightly seal the soil immediately after application. Use soil fumigants only as directed on the label. In some limited situations soil fumigants can be applied in the spring.

Correct soil moisture, temperature, and soil structure are required for effective control. Take special care to seal fumigants in target zone for required time. You can do this by soil packing or by immediate tarping.

**Vydate L**® (*RUP*) at the following rates:

- **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 3 weeks after transplanting. Apply again 3 weeks after first treatment.

**Tarnished Plant Bug**

Apply if there are 2-4 tarnished plant bugs per 20 plants.

**Recommended Products**

**Baythroid XL**® at 2.4-3.2 fl. oz. per acre. 0-day PHI. *RUP.*

**Beleaf 50SG**® at 2-2.8 oz. per acre. 0-day PHI.

**Mustang Maxx**® at 3.2-4 oz. per acre. 1-day PHI. *RUP.*

**Pyrenone**® at 1-12 fl. oz. per acre. 0-day PHI.

Various **Sevin**® formulations are available. See labels for rates. 14 day PHI.

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**Slugs**

**Recommended Products**

**Deadline M-Ps**® (4B) at 20-40 lbs. per acre, or **Metaldehyde 3.5G**® at 30-40 lbs. per acre. Apply between rows. Avoid contact to edible product.

**Thrips, Whiteflies**

**Recommended Products**

**Assail**® (70WP) at 1.1-1.7 oz. per acre. **Whitefly suppression only.** 7-day PHI.

**Exirel**® at 13.5-20.5 oz. per acre. Use with an effective adjuvant.

**Movento**® at 4.0-5.0 fl. oz. per acre. **Whiteflies only.** Must be tank-mixed with an adjuvant with spreading and penetrating properties. 3-day PHI.

**Sivanto**® at 10.5-14 fl. oz. per acre. **Whiteflies only.** Can be applied as a soil treatment or foliar treatment. See label for application methods.

**Torac**® at 21 oz. per acre. Do not exceed 2 applications per crop per season.

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This is a reduced-risk pesticide. See page 37 for details.
# Cole Crops and Brassica Leafy Greens

## Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Collards, Kale, Mustard, and Turnip Greens

<table>
<thead>
<tr>
<th>BROCCOLI Varieties</th>
<th>Maturity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leprechaun</td>
<td>early</td>
<td>Large beads, slightly domed</td>
</tr>
<tr>
<td>Regal</td>
<td>early</td>
<td>Medium to small beads, firm domed heads, side shoots</td>
</tr>
<tr>
<td>Green Comet</td>
<td>early</td>
<td>Excellent center head and large side shoots</td>
</tr>
<tr>
<td>Emperor</td>
<td>early-mid</td>
<td>Few side shoots</td>
</tr>
<tr>
<td>Green Valiant</td>
<td>mid</td>
<td>Small beads, firm head</td>
</tr>
<tr>
<td>Premium Crop</td>
<td>mid</td>
<td>Large center heads, few side shoots</td>
</tr>
<tr>
<td>Goliath</td>
<td>mid</td>
<td>Large, tight heads</td>
</tr>
<tr>
<td>Gypsy</td>
<td>mid</td>
<td>Smooth, domed heads</td>
</tr>
<tr>
<td>Marathon</td>
<td>late</td>
<td>Domed</td>
</tr>
<tr>
<td>Triathlon</td>
<td>late</td>
<td>Excellent crown cut or bunching broccoli in Missouri</td>
</tr>
<tr>
<td>Arcadia</td>
<td>late</td>
<td>Small beads, very domed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BRUSSELS SPROUTS Varieties</th>
<th>Maturity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prince Marvel</td>
<td>medium</td>
<td>Medium sprouts, large plants</td>
</tr>
<tr>
<td>Oliver</td>
<td>early</td>
<td>Large sprouts, short plants</td>
</tr>
<tr>
<td>Dasher</td>
<td>late</td>
<td>Medium sprouts</td>
</tr>
<tr>
<td>Jade Cross</td>
<td>early</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CABBAGE Varieties</th>
<th>Season</th>
<th>Head Size</th>
<th>Yellows Resistance</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stone Head</td>
<td>very early</td>
<td>small</td>
<td>no</td>
<td>Solid head for an early type</td>
</tr>
<tr>
<td>Head Start</td>
<td>early</td>
<td>medium</td>
<td>no</td>
<td>Excellent field holding for an early type</td>
</tr>
<tr>
<td>Charmant</td>
<td>early</td>
<td>small</td>
<td>yes</td>
<td>Flattened round head. Tolerant to tipburn, black speck</td>
</tr>
<tr>
<td>Conquest</td>
<td>main</td>
<td>medium</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Bronco</td>
<td>late</td>
<td>medium</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Green Cup</td>
<td>main</td>
<td>medium-large</td>
<td>yes</td>
<td>High tolerance to black rot-tolerant to thrips, tipburn, heat, cold.</td>
</tr>
<tr>
<td>Blue Pak</td>
<td>main</td>
<td>medium-large</td>
<td>yes</td>
<td>Good tip burn tolerance, very thrips tolerant</td>
</tr>
<tr>
<td>Cheers</td>
<td>late</td>
<td>large</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Rio Verde</td>
<td>late</td>
<td>large</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Hinova</td>
<td>late</td>
<td></td>
<td>yes</td>
<td>For processing, flat, rounded heads, resistant to tipburn; tolerant to black rot, black speck; susceptible to thrips</td>
</tr>
</tbody>
</table>

| Red               |        |           |                   |         |
| Red Acre          | main   | small    | no                | A firm head, open pollinated |
| Regal Red         | early  | medium   | no                | Early for a red cabbage |
| Ruby Perfection   | late   | small    | no                | Deep red color, thrips tolerant |

<table>
<thead>
<tr>
<th>CAULIFLOWER Varieties</th>
<th>Season</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow Crown-F1 Hybrid</td>
<td>early</td>
<td>Good and reliable for spring and early fall production</td>
</tr>
<tr>
<td>Fremont F1</td>
<td>2nd early</td>
<td>Forming heads should be blanched</td>
</tr>
<tr>
<td>Snowball Y improved op</td>
<td>main</td>
<td>Forming heads should be blanched</td>
</tr>
<tr>
<td>Andes op</td>
<td>main</td>
<td>Forming heads should be blanched</td>
</tr>
<tr>
<td>White Sails F1</td>
<td>main</td>
<td>Forming heads should be blanched</td>
</tr>
<tr>
<td>Self-Blanche op</td>
<td>late</td>
<td>No tying necessary if plants are fertilized properly</td>
</tr>
<tr>
<td>Silver Streak op</td>
<td>late</td>
<td>For fall harvest</td>
</tr>
</tbody>
</table>

For trial only: Candid Charm (2nd early), Cashmere (early), Cumberland (main), Majestic (early)
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.

Mustard: Rows 1 to 1.5 feet apart. Plants 10 to 12 inches apart in row. Seed 3 to 5 pounds per acre.

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. P₂O₅: 25 to 200 pounds per acre. K₂O: 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. P₂O₅: 0 to 150 pounds per acre. K₂O: 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.

Disease Control

Alternaria Leaf Spot

Practice a 3-4 year crop rotation to non-cruciferous crops. Incorporate crop residue to speed up decomposition. Use pathogen-free seed, and keep cruciferous weeds out of growing areas.
**Recommended Products**

**Bravo**, **Echo**, **Equus**, and **Initiate** formulations are labeled at various rates. *Not for collard, kale, mustard, or turnip greens. 7-day PHI.*

**Cabrio** at the following rates:
- **Turnip greens**: 8-12 oz. per acre.
- **All other labeled crops**: 12-16 oz. per acre.

3-day PHI for collard, kale, and mustard. 0-day PHI for all others.

**Endura 70WG** at 6-9 oz. per acre. *Not for turnip greens.*

14-day PHI for collard, kale, and mustard. 0-day PHI for all others.

**Cabrio** at the following rates:
- **Turnip greens**: 8-12 oz. per acre.
- **All others**: 12-16 oz. per acre.

3-day PHI for collard, kale, and mustard. 0-day PHI for all others.

**Endura 70WG** at 6-9 oz. per acre. *Not for turnip greens.*

14-day PHI for collard, kale, and mustard. 0-day PHI for all others.

**Fixed copper** formulations at various rates. Read labels carefully to make sure your crop is included. Copper applications may slow the spread of black rot.

**Club Root**

Plant only disease-free transplants. Club root may be brought in with diseased transplants.

Rotate crops 5 years or more with a non-cruciferous crop between plantings. Avoid poorly drained soils with a history of club root. Serious losses can be avoided by raising the pH to 7.2-7.3.

**Recommended Products**

**Blocker 4F** at 3 pts. per acre in transplant solution or banded soil application, or **Blocker 10G** at 5.15 lbs. per 1,000 feet of linear row.

**Omega 500F** at 6.45 fl. oz. per 100 gals. of water. Apply 3.4 fl. oz. of solution to each plant. Apply at transplant as a soil drench. *Not for edible turnip roots.* 20-day PHI for leafy greens. 50-day PHI for heading vegetables.

**Terraclor 75WP** flowable fungicide. Rate depends on application method. *Not for turnip.* Terraclor may be used in a transplant solution or in a band or broadcast application at planting.

**Downy Mildew**

Practice a 2 year crop rotation. Rotating to non-cruciferous crops may reduce pathogen populations and increase fungicide efficacy. Plant disease-resistant broccoli varieties — several varieties with resistance are available.

**Recommended Products**

**Actigard** at 0.5-1 oz. per acre. Do not apply to stressed plants. 7-day PHI.

**Agri-Fos 400** at 2 teaspoons-2 fl. oz. per gal. of water. *Not for turnip greens.* 0-day PHI.

**Bravo**, **Echo**, and **Equus** formulations are labeled at various rates. *Not for use on collard, kale, mustard, or turnip greens.* 7-day PHI.

**Cabrio** at the following rates:
- **Turnip greens**: 8-12 oz. per acre.
- **All others**: 12-16 oz. per acre.

3-day PHI for collard, kale, and mustard. 0-day PHI for all others.

**Forum** at 6 fl. oz. per acre. 0-day PHI.

**Phostrol** at 2.5-5 pts. per acre. *Not for turnip greens.*

**Presidio** at 3-4 oz. per acre. *Not for turnip.* Must be tank-mixed with another effective fungicide with a different mode of action. 2-day PHI.

**Prophyt** at 2-4 pts. per acre. *Not for turnip greens.* 0-day PHI.

**Quadris** at 6.2-15.4 fl. oz. per acre. 0-day PHI.
Ranman SC® at 2.75 fl. oz. per acre. 0-day PHI.

Reason® at 5.5-8.2 fl. oz. per acre. 2-day PHI.

Revus 2.09SC® at 8 fl. oz. per acre. Not for turnip greens. 1-day PHI.

Ridomil Gold Bravo SC® at 1.5 pts. per acre. 0-day PHI.

Satori® at 6.2-15.4 fl. oz. per acre. 0-day PHI.

Zampro® at 14 fl. oz. per acre. Not for turnips. 0-day PHI.

This is a reduced-risk pesticide. See page 37 for details.

This is a biopesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

Ranman SC® at 2.75 fl. oz. per acre. 0-day PHI.

Reason® at 5.5-8.2 fl. oz. per acre. 2-day PHI.

Revus 2.09SC® at 8 fl. oz. per acre. Not for turnip greens. 1-day PHI.

Ridomil Gold Bravo SC® at 1.5 pts. per acre. 0-day PHI.

Satori® at 6.2-15.4 fl. oz. per acre. 0-day PHI.

Zampro® at 14 fl. oz. per acre. Not for turnips. 0-day PHI.

1-day PHI.

Ridomil Gold Bravo SC® at 8 fl. oz. per acre. 0-day PHI.

Satori® at 6.2-15.4 fl. oz. per acre. 0-day PHI.

Zampro® at 14 fl. oz. per acre. Not for turnips. 0-day PHI.

Fusarium Yellows

Plant yellows-resistant varieties. Disease may be seedborne.

Ridomil Gold Bravo SC® at 8 fl. oz. per acre. 0-day PHI.

Satori® at 6.2-15.4 fl. oz. per acre. 0-day PHI.

Zampro® at 14 fl. oz. per acre. Not for turnips. 0-day PHI.

1-day PHI.

Fusarium Yellows

Plant yellows-resistant varieties. Disease may be seedborne.

Powdery Mildew

Resistant cultivars exist for Brussels sprout and cabbage.

Recommended Products

Cabrio® at the following rates:

- Turnip greens: 8-12 oz. per acre.
- All others: 12-16 oz. per acre.

3-day PHI for collard, kale, and mustard. 0-day PHI for all others.

Endura 70WG® at 6-9 oz. per acre. Not for turnip greens. Suppression only. 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 14-day PHI for all others.

Fontelis® at 14-30 fl. oz. per acre. 0-day PHI.

Microthiol Dispers® at 3-10 lbs. per acre. 0-day PHI.

Rhizoctonia Diseases

Clean and sanitize transplant trays, benches, etc.

Recommended Products

Bottom Rot

Endura 70WG® at 6-9 oz. per acre. Not for turnip greens. Suppression only. 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 14-day PHI for all others.

Fontelis® at 14-30 fl. oz. per acre. 0-day PHI.

Rhizoctonia Blight

Cabrio® at the following rates:

- Turnip greens: 8-12 oz. per acre.
- All others: 12-16 oz. per acre.

3-day PHI for collard, kale, and mustard. 0-day PHI for all others.

Recommended Products

- Terraclor® flowable or granular. Rate depends on application method. Not for turnip. May be used in a transplant solution or in a band or broadcast application at planting. Raise seedlings in seedbeds that are disinfected by steam or chemical fumigants.

Sclerotinia Stem Rot

Recommended Products

Cabrio EG® at 12-16 oz. per acre. Collards, kale, and mustard only. 3-day PHI.

Endura 70WG® at 6-9 oz. per acre. Not for turnip greens. 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 14-day PHI for all others.

Fontelis® at 16-30 fl. oz. per acre. 0-day PHI.

White Rust

Use crop rotations of 2-3 years, practice sanitation, use pathogen-free seed, and use resistant varieties when possible.

Recommended Products

Cabrio EG® at the following rates:

- Cabbage, broccoli, cauliflower, collards, kale, mustard: 12-16 oz. per acre.
- Turnip: 8-16 oz. per acre.

3-day PHI for collard, kale, and mustard. 0-day PHI for all others.

Quadris® at 6.0-15.5 fl. oz. per acre. 0-day PHI.

Reason® at 8.2 fl. oz. per acre. 2-day PHI.

Weed Control

For specific weeds controlled by each herbicide, check Table 25 on page 66.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Gramoxone Inteon 2L® at 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. RUP.

Glyphosate® products at 0.75-3.75 lbs. acid equivalent (ae) per acre. Use formulations containing 3 lbs. ae/gal. (4 lbs. isopropylamine salt/gal.) at 1-5 pts. per acre, or formulations containing 4.5 lbs. ae/gal. (5 lbs. potassium salt/gal.) at 0.66-3.3 pts. per acre. Not for turnip greens. 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. See label for suggested application volume and adjuvants. 14-day PHI.

Terraclor® flowable or granular. Rate depends on application method. Not for turnip. May be used in a transplant solution or in a band or broadcast application at planting. Raise seedlings in seedbeds that are disinfected by steam or chemical fumigants.

Rhizoctonia Diseases — Wirestem

Recommended Products

Aim EC® at 0.5-2 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
Preemergence Broadleaves and Grasses

Recommended Products

Command 3ME® at the following rates:

- **Cabbage transplants:** up to 1.3 pts. per acre.
- **Broccoli, Brussels sprouts, and cauliflower:** 0.67 pt. per acre.

- **Not for collards, kale, mustard greens, or turnip greens.** Apply before planting or by incorporation 1-2 inches before transplanting or after emergence. Do not exceed 1.3 pts. per acre or 1 application per crop per season. 30-day PHI.
- **Dual Magnum®** in Indiana, Michigan, and Ohio only at the following rates:
  - **Broccoli raab, Chinese cabbage (bok choy), collards, kale, mizuna, mustard greens, mustard spinach, rape greens, and turnip greens:** 0.67-1.3 pts. per acre. Apply after transplanting before weeds or crop emerges, or apply broadcast after emergence of crops have 1-2 true leaves. Do not exceed 1.3 pts. per acre or 1 application per crop per season. 30-day PHI.
  - **Prowl H20®** at 1-2.1 pts. per acre. **Broccoli, Brussels sprouts, cabbage, and cauliflower only.** Apply to soil between rows 1-3 days after transplanting, or 2-4 leaf stage after direct seeding. Spray contact with plants may cause crop stunting. 60-day PHI for broccoli. 70-day for all other labeled crops.

Trifluralin products at 0.5-0.75 lbs. a.i. per acre. Use 4EC formulations at 1-1.5 pts. per acre. **Not for turnip greens.** Use low rate on soils with less than 2% organic matter. Apply before planting or transplanting and incorporate 2-3 inches immediately. Not effective on muck or high organic matter soils. Delayed emergence or stunting may occur when soil is cool.

Preemergence Broadleaves

Recommended Products

**Spartan 4F®** at 2.25-12 fl. oz. per acre. **Transplanted cabbage for processing only. Not for broccoli, Brussels sprouts, fresh market cabbage, cauliflower, collards, kale, mustard or turnip greens.** 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.

**Spartan Charge®** at 2.9-15.2 fl. oz. per acre. **Transplanted cabbage only. Not for broccoli, cauliflower, Brussels sprouts, collards, kale, mustard greens, or turnip greens.** 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.

**Goal 2XL®** at 1-2 pts. per acre. **Not for direct-seeded crops. Not for Brussels sprouts, collards, kale, mustard greens, or turnip greens.** Use lower rate on coarse-textured soils. Apply after preparing soil but before transplanting. Transplant within 7 days of application.

**Stinger 3L®** at 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. 30-day PHI.

Preemergence Grasses

Recommended Products

**Dacthal W-75®** at 6-14 lbs. per acre, or **Dacthal Flowable®** at 6-14 pts. per acre. Apply at seedling or transplanting. May be incorporated. May be applied over top of transplants.

**Prefar 4E®** at 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply before transplanting and incorporate 1-2 inches or apply after transplanting before crop emerges and irrigate within 24 hours.

Postemergence

Recommended Products

**Glyphosate products.** See details above under Burndown or Directed/Shielded Application.

**Aim EC®.** See details above under Burndown or Directed/Shielded Application.

Postemergence Grasses

Recommended Products

**Clethodim products** at the following rates:

- **Select Max®** at 9-16 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

- **2EC formulations of clethodim products** at 6-8 fl. oz. per acre. Use 2EC formulations with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations 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. 14-day PHI for greens. 30-day PHI for broccoli, Brussels sprouts, cauliflower, cabbage, and kohlrabi.

**Poast 1.5E®** at 1-1.5 pts. per acre, plus 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. 14-day PHI for turnip greens. 30-day PHI for all others.
# Herbicides for Cole Crops and Leafy Greens

<table>
<thead>
<tr>
<th>Product (REI/PHI)</th>
<th>Common Name</th>
<th>Timing and Application Location Relative to Crop</th>
<th>Incorporated</th>
<th>Timing Relative to Weeds</th>
<th>Weed Groups Controlled</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before seeding</td>
<td>After seeding before emergence</td>
<td>Before transplanting</td>
<td>Post emergence between rows only</td>
<td>Post emergence</td>
</tr>
<tr>
<td>Aim EC* (12h/-)</td>
<td>carfentrazone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Command 3ME* (12h/45d)</td>
<td>clomazone</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dacthal* (12h/-)</td>
<td>DCPA</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Devrinol 50DF* (12h/-)</td>
<td>napropamide</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual Magnum* (24h/21d)</td>
<td>s-metolachlor</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goal 2XL* (12h/-)</td>
<td>oxfluorfen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gramoxone Inteon 2L* (12h to 24h/-)</td>
<td>paraquat</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poast* (12h/14-30d)</td>
<td>sethoxydim</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prefar 4E* (12h/-)</td>
<td>bensulide</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roundup*, others (12h/14d)</td>
<td>glyphosate</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select Max*, others (12h/14-30d)</td>
<td>clethodim</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spartan DF* (12h/1d)</td>
<td>sulfentrazone</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spartan Charge* (12h/-)</td>
<td>sulfentrazone plus carfentrazone</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stinger*</td>
<td>clopyralid</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treffan*, others (12h/-)</td>
<td>trifluralin</td>
<td>X</td>
<td>X</td>
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</tr>
</tbody>
</table>

For effectiveness against specific weeds, see Table 25 on page 66, 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.
Insect Control

Aphids, Leafminers
Conserve natural enemies.
Limit the use of insecticides to conserve predators and parasites.

Recommended Products

**Actara®** (25WDG) at 1.5-3 oz. per acre. *Aphids only.*
Do not exceed 11 oz. per acre pre season. 0-day PHI for broccoli, Brussels sprouts, cabbage and cauliflower. 7-day PHI for leafy greens.

**Admire PRO** *(4.6F)* at the following rates:
- **Soil applications:** 4.4-10.5 fl. oz. per acre. 21-day PHI.
- **Foliar applications:** 1.3 fl. oz. per acre. 7-day PHI.
Do not exceed 10.5 fl. oz. per acre per season.

**Assail®** (30SG) at 2-4 oz. per acre. *Aphids only.* Do not exceed 20 oz. per acre per season. 7-day PHI.

**Belay®** (2.13SC) at 3-4 fl. oz. per acre. *Aphids only.* 21-day PHI.

**Beleaf®** (50SG) at 2-2.8 oz. per acre. *Aphids only.* 0-day PHI.

**Dimethoate 400** or **Dimethoate 4E** at 0.5-1 pt. per acre, or Dimethoate 2.67EC at 0.75-1.5 pts. per acre. 7-day PHI for broccoli and cauliflower. 10-day PHI for Brussels sprouts. 14-day PHI for kale and mustard.

**Entrust®** (2SC) at 4-10 fl. oz. per acre. *Leafminers only.* Do not exceed 29 fl. oz. per acre per year. 1-day PHI.

**Fulfill®** (50WDG) at 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per crop per season. 7-day PHI.

**Movento®** (2SC) at 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. 1-day PHI.

**M-Pede®** at 1-2% by volume. Must contact aphids to be effective. 0-day PHI.

**Orthene®** (97S) at 0.5-1.0 lb. per acre. *Brussels sprouts and cauliflower only.* Do not exceed 4 1/8 lbs. per acre per season. 14-day PHI. *RUP*

**Platinum®** (2SC) soil application at 5-11 fl. oz. per acre. Do not exceed 11 fl. oz. per acre per season. *Aphids only.* 30-day PHI.

**Radiant®** (1SC) at 6-10 fl. oz. per acre. *Leafminers only.* Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

**Rimon®** (0.83EC) at 6-12 fl. oz. per acre. *Leafminers only.* Do not exceed 24 fl. oz. per acre per season. 7-day PHI.

**Sivanto®** (200SL) at 7-12 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. *Aphids only.* 1-day PHI.

**Trigard®** (75WP) at 2.66 oz. per acre. *Leafminers only.* Do not exceed 6 applications per season. 7-day PHI.

**Venom®** (70SG) at the following rates:
- **Foliar applications:** 1-4 oz. per acre. Do not exceed 6 oz. per acre per season. 1-day PHI.
- **Soil applications:** 5-7.5 oz. per acre. Do not exceed 12 oz. per acre per season. 21-day PHI.

Caterpillars (Imported Cabbageworms, Cabbage Loopers, Diamondback Moth Larvae, Cross-Striped Cabbageworms)

Recommended Products

**Ambush®** (2EC) at 3.2-12.8 fl. oz. per acre. Rate varies with crop — see label. *Broccoli, Brussels sprouts, and cauliflower:* Do not exceed 51 fl. oz. per acre per season. *Cabbage:* Do not exceed 64 fl. oz. per acre per season. 1-day PHI. *RUP*

**Asana XL®** (0.66EC) at 2.9-9.6 fl. oz. per acre. *Cole crops and collards only.* Cole crops: Do not exceed 76.8 fl. oz. per acre per season. 3-day PHI. Collards: Do not exceed 38.4 fl. oz. per acre per season. 7-day PHI. *RUP*

**Avaunt®** (30WDG) at 2.5-3.5 oz. per acre. Do not exceed 14 oz. per acre per season. 3-day PHI.

**Baythroid XL®** (1EC) at 1.6-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 0-day PHI. *RUP*

**Brigade®** (2EC) at 2.1-6.4 fl. oz. per acre (do not exceed 1 qt. per acre per season), or **Brigade®** (WSB) at 5.3-16 oz. per acre (do not exceed 80 oz. per acre per season). 7-day PHI. *RUP*

**Confirm®** (2F) at 6.0-8.0 fl. oz. per acre. Do not exceed 56 fl. oz. per season. 7-day PHI.

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 comer: This is a reduced-risk pesticide. See page 37 for details.
 comer: This is a biopesticide. See page 37 for details.
 comer: May be acceptable for use in certified organic production. Check with your certifier before use.
**Cole Crops - Insect Control**

**Coragen**® (1.67SC) at 3.5-5.0 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. 3-day PHI.

**Entrust**® (2SC) at 1.5-6.0 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

**Exirel**® (0.83SE) at 7-17 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per season. 1-day PHI.

**Intrepid**® (2F) at 4-10 fl. oz. per acre. 1-day PHI.

**Larvin**® (3.2F) at 16-40 fl. oz. per acre. *Broccoli, cabbage, and cauliflower only*. Do not exceed 160 fl. oz. per acre per season. 7-day PHI. *RU P.*

**Mustang Maxx**® (0.8EC) at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI. *RU P.*

**Orthene**® (97S) at 1 lb. per acre. *Brussels sprouts and cauliflower only*. Do not exceed 4 1/8 lbs. per acre per season. 14-day PHI.

**Permethrin**® (3.2EC) at 2-8 fl. oz. per acre. Rate varies with crop — see label. Do not exceed 32 fl. oz. per acre per season for broccoli. Do not exceed 16 fl oz. per acre per season for Brussels sprouts, cabbage, and cauliflower. 1-day PHI. *RU P.*

**Proclaim**® (5SG) at 2.4-4.8 oz. per acre. Do not exceed 28.8 oz. per acre per season. Allow at least 7 days between applications. 7-day PHI for brassica head and stem vegetables. 14-day PHI for brassica leaf vegetables. *RU P.*

**Radiant**® (1SC) at 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

**Rimon**® (0.83EC) at 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 7-day PHI.

**Sevin XLR PLUS**® (4F) at 1-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 3-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 14-day PHI for collards, kale, and mustard.

**Warrior II**® (2.08CS) at 0.96-1.92 fl. oz. per acre. *Cole crops only*. Do not exceed 15.36 fl. oz. per acre per season. 1-day PHI. *RU P.*

**Flea Beetles**

**Recommended Products**

**FarMore FI400**® commercial seed treatment for leafy Brassicas.

**Actara**® (25WDG) at 1.5-3 oz. per acre. Do not exceed 11 oz. per acre per season. 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 7-day PHI for leafy greens.

**Ambush**® (2EC) at 6.4 fl. oz. per acre. Do not exceed 51 fl. oz. per acre per season for broccoli, Brussels sprouts, and cauliflower. Do not exceed 64 fl. oz. per acre per season for cabbage. 1-day PHI. *RU P.*

**Asana XL**® (0.66EC) at 5.8-9.6 fl. oz. per acre. *Cole crops and collards only*. Cole crops: Do not exceed 76.8 fl. oz. per acre per season. 3-day PHI. Collards: Do not exceed 38.4 fl. oz. per acre per season. 7-day PHI. *RU P.*

**Baythroid XL**® (1EC) at 2.4-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 0-day PHI. *RU P.*

**Belay**® (2.13SC) at 3-4 fl. oz. per acre. 21-day PHI.

**Brigade**® (2EC) at 2.1-6.4 fl. oz. per acre (do not exceed 1 qt. per acre per season), or **Brigade**® (WSB) at 5.3-16 oz. per acre (do not exceed 80 oz. per acre per season). 7-day PHI. *RU P.*

**Kryocide**® at 8-16 lbs. per acre. Do not exceed 96 lbs. per acre per season. 7-day PHI for broccoli, Brussels sprouts, and cauliflower. 14-day PHI for cabbage and collards.

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**Caterpillar Thresholds**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Stage</th>
<th>% Infested</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Diamondback Moth Larvae</td>
</tr>
<tr>
<td><strong>Cabbage — Fresh</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>seed bed</td>
<td></td>
<td>not applicable</td>
</tr>
<tr>
<td>transplant to cupping</td>
<td></td>
<td>50% with ≥ 5 larvae/plant</td>
</tr>
<tr>
<td>cupping to early head</td>
<td></td>
<td>50% with ≥ 5 larvae/plant</td>
</tr>
<tr>
<td>early head to harvest</td>
<td></td>
<td>10% with ≥ 1 larva/plant</td>
</tr>
<tr>
<td><strong>Broccoli, Cauliflower</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>seedbed</td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>transplant to first curl</td>
<td></td>
<td>40%</td>
</tr>
<tr>
<td>first curl to harvest</td>
<td></td>
<td>10%</td>
</tr>
</tbody>
</table>
Larvin® (3.2F) at 16-32 fl oz. per acre. *Broccoli, cabbage, and cauliflower only.* Do not exceed 160 fl oz. per acre per season. 7-day PHI. RUP.

**Mustang Maxx®** (0.8EC) at 2.24-4.0 fl oz. per acre. Do not exceed 24 fl oz. per acre per season. Allow 7 days between applications. 1-day PHI. RUP.

Permethrin® (3.2EC) at 2-8 fl oz. per acre. Rate varies with crop — see label. Do not exceed 32 fl oz. per acre per season for broccoli. Do not exceed 16 fl oz. per acre per season for Brussels sprouts, cabbage, and cauliflower. 1-day PHI. RUP.

Prokil Cryolite® (50D) at 15-30.5 lbs. per acre. Do not exceed 184 lbs. per acre per season. 7-day PHI for broccoli, Brussels sprouts, and cauliflower. 14-day PHI for cabbage and collards.

Sevin XLR PLUS® (4F) at 0.5-1 qt. per acre. Do not exceed 6 qts. per acre per crop. 3-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 14-day PHI for collards, kale, and mustard.

**Warrior II®** (2.08CS) at 1.28-1.92 fl oz. per acre. *Cole crops only.* Do not exceed 15.36 fl oz. per acre per season. 1-day PHI. RUP.

**Harlequin Bug and Other Stink Bugs**

**Recommended Products**

Azera® at the following rates:

- **Harlequin bug nymphs:** 2 fl oz. per acre.
- **Adult harlequin bug and other stink bugs:** 48 fl oz. per acre. Use higher rates (48 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. 0-day PHI.

Baythroid XL® (1EC) at 2.4-3.2 fl oz. per acre. Do not exceed 12.8 fl oz. per acre per season. 0-day PHI. RUP.

Belay® (2.13SC) at 3-4 fl oz. per acre. 21-day PHI.

Brigade® (2EC) at 2.1-6.4 fl oz. per acre (do not exceed 1 qt. per acre per season), or Brigade® (WSB) at 5.3-16 oz. per acre (do not exceed 80 oz. per acre per season). 7-day PHI. RUP.

Malathion 5EC® at 1.5 pts. per acre, or Malathion 57EC® at 1 pt. per 100 gals. of water per acre. *Harlequin bug on collards only.* PHI varies by crop — check the label.

Mustang Maxx® (0.8EC) at 3.2-4 oz. per acre. Do not exceed 24 fl oz. per acre per season. 1-day PHI. RUP.

Rimon® (0.83EC) at 6-12 fl oz. per acre. Do not exceed 24 oz. or 2 applications per acre per season. 7-day PHI.

Sevin XLR PLUS® (4F) at the following rates:

- **Harlequin bug:** 0.5-1 qt. per acre.
- **Other stink bugs:** 1-2 qts. per acre.

Do not exceed 6 qts. per acre per season. 3-day PHI.

Warrior II® (2.08CS) at 1.28-1.92 fl oz. per acre. *Cole crops only.* Do not exceed 15.36 fl oz. per acre per season. 1-day PHI. RUP.

**Root Maggots**

Cabbage maggot injury is usually more severe when fields have decaying organic matter present, such as plowed down cover crop, or when cool, wet conditions prevail.

**Recommended Products**

For use in transplanting water, mix any one of these products in 50 gallons of water. Refer to the comments for each product or product labels regarding drench applications. The transplant mixture application (insecticide plus water) will require about 200-300 gallons of water per acre, based on the number of plants set per acre.

Capture LFR® at 0.2-0.39 fl oz. per 1,000 linear ft. of row. See label. RUP.

Diazinon AG500® at 2-3 qts. per acre in 50 gals. of water (for drench application). Water treatments may reduce stands due to plant stress at time of transplanting. Make drench application at the rate of 0.5-1 cup per plant, either by hand or tractor-mounted sprayer with drop nozzles to direct spray to base of plants. In some areas, cabbage maggots are exhibiting resistance to diazinon, resulting in control failures. 4-day PHI. RUP.

Lorsban® products at the following rates:

- **Cauliflower:** Lorsban 4EC® (RUP) at 1.6-2.4 fl oz. per 1,000 linear ft. of row, or Lorsban 75WG® (not RUP) at 1.1-1.6 fl oz. per 1,000 linear ft. of row.

Broccoli, Brussels sprouts, cabbage, collards, and kale:

- **Lorsban 4EC®** (RUP) at 1.6-2.75 fl oz. per 1,000 linear ft. of row, or Lorsban 75WG® (not RUP) at 1.1-1.8 fl oz. per 1,000 linear ft. of row.

Apply as a water-based spray directed at the base of plants immediately after setting in field. Use a minimum of 40 gallons of total spray per acre. Do not apply as a foliage application. Do not exceed one application per acre per season. 30-day PHI.
**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.

**Recommended Products**

For use in transplanting water, mix any one of these products in 50 gallons of water. Refer to the comments for each product or product labels regarding drench applications. The transplant mixture application (insecticide plus water) will require about 200-300 gallons of water per acre, based on the number of plants set per acre.

- **Deadline M-Ps** (4B) at 25 lbs. per acre. 0-day PHI.
- **Sluggo** (1B) at 20-44 lbs. per acre, or at 0.5-1 lb. per square ft. 0-day PHI.

**Thrips**

Some cabbage varieties are tolerant of thrips, such as Bantly, Bravo, Brutus, King Cole, Little Rock, Manrico, Rio Granda, Rio Verde, Ruby Perfection, Starski, Stonar, SuperKraut, Titanic 90, Zerlina, and others.

**Recommended Products**

- **Actara** (25WDG) at 3-5.5 oz. per acre. Do not exceed 11 oz. per acre pre season. 0-day PHI for broccoli, Brussels sprouts, cabbage, and cauliflower. 7-day PHI for leafy greens.
- **Admire PRO** (4.6F) at the following rates:
  - Soil applications: 4.4-10.5 fl. oz. per acre. 21-day PHI.
  - Foliar applications: 1.3 fl. oz. per acre. 7-day PHI.

  Do not exceed 0.38 lb. a.i. per acre per season.

- **Ambush** (2EC) at 3.2-12.8 oz. per acre. Rate varies with crop — see label. Not for cabbage. Do not exceed 51 fl. oz. per acre pre season for broccoli, Brussels sprouts, and cauliflower. 1-day PHI. **RUP**.
- **Assail** (30SG) at 4 oz. per acre. Do not exceed 0.375 lb. a.i. per acre per season. 7-day PHI.
- **Baythroid XL** (1EC) at 0.8-1.6 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre pre season. 0-day PHI. **RUP**.
- **Brigade** (2EC) at 2.1-6.4 fl. oz. per acre, or **Brigade** (WSB) at 5.3-16 oz. per acre. Do not exceed 0.5 lb. a.i. per acre per season. 7-day PHI. **RUP**.
- **Entrust** (2SC) at 4-10 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. 1-day PHI.
- **Exirel** (0.8SE) at 13.5-20.5 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per season. 1-day PHI.
- **Mustang Maxx** (0.8EC) at 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI. **RUP**.
- **Radiant SC** (1SC) at 6-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.
- **Warrior II** (2.08CS) at 1.28-1.92 fl. oz. per acre. **Cole crops only**. Do not exceed 15.36 fl. oz. per acre per season. 1-day PHI. **RUP**.

Avoid using broad-spectrum insecticides early in the season to preserve predators of pests like this diamondback moth larva.
Cucurbit Crops

Types and Varieties

**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.

Disease Control for Squash and Pumpkin

**Angular Leaf Spot**

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.

**Recommended Products**

Several copper-based bactericides are effective against angular leaf spot. Dithane® and Manzate® may help manage angular leaf spot when used with fixed copper products.

**Bacterial Fruit Blotch**

Bacterial fruit blotch is much more likely to occur on watermelon than on squash or pumpkin. See the bacterial fruit blotch section in Disease Control for Cantaloupe, Cucumber, and Watermelon, page 112.
**Bacterial Leaf and Fruit Spot**

Bacterial leaf and fruit spot occurs primarily on pumpkin and winter squash. Symptoms on leaves may occur throughout the season. However, only lesions on fruit 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 may survive on crop residue and be transmitted on seed. All squash and pumpkin varieties appear to be susceptible. Symptoms may be similar to angular leaf spot.

**Winter/Off-season:** Rotate crops at least 3 years with cucurbit crops, and practice fall tillage. May be seedborne. Avoid problem fields.

**Planting:** Treat with fixed copper compounds mixed with mancozeb products if symptoms are present.

**Vine Touch:** Apply fixed copper sprays when fruit is softball-sized. Tank-mix copper and mancozeb products. Continue applications until fruit set is complete.

**Harvest:** Do not save seed from affected fields. Identify fruit problems.

**Recommended Products**

- **Copper** applications at 7-day intervals beginning when fruit are 4-5 inches in diameter. Applying copper mixed with mancozeb (Dithane®, Manzate®) is more effective than copper alone.

**Bacterial Wilt**

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 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.

**Damping-off**

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.

**Recommended Products**

- **Apron XL LS** (mefenoxam) seed treatment at 0.64 fl. oz./100 lbs. seed before sowing. This seed treatment will prevent damping-off caused by *Phytophthora* and *Pythium*.

- **Previcur Flex®** See label for greenhouse uses and details about managing damping-off caused by *Pythium* species.

- **Ridomil Gold SL®** at 1-2 pts. per acre. For use on damping-off caused by *Pythium* species.

**Downy Mildew**

The downy mildew pathogen does not survive in the Midwest, so it usually arrives in the Midwest via the wind. Downy mildew may not occur in the Midwest until August or September and in some years, does not occur in the Midwest at all.

Strains of the downy mildew fungus 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 susceptible to resistance. See Fungicide Resistance Management (page 76) for more information.

**Winter/Off-season:** The disease is unaffected by crop rotation.

**Planting:** Begin scouting in July. You can follow disease progress in the Purdue Extension Vegetable Crops Hotline bulletin or at cdm.ipmPIPE.org. Apply specialized systemic downy mildew fungicides plus chlorothalonil (Bravo®) if disease is observed in the area. Applying chlorothalonil before infection delays downy mildew occurrence.
**Recommended Products**

**Bravo**, **Echo**, **Equus**, and **Initiate** are labeled for use at various rates. 0-day PHI.

**Catamaran** at 6 pts. per acre. 1-day PHI.

**Forum 4.18SC** at 6 fl. oz. per acre. 0-day PHI.

**Gavel 75DF** 1.5-2.0 lbs. per acre. 5-day PHI.

**Mancozeb** products (including Dithane or Manzate) are labeled at various rates. Some mancozeb formulations may not be labeled for pumpkin. 5-day PHI.

Several **phosphite or phosphorous acid** products are labeled at various rates (including Agri-Fos, Phostrol, Prophyt, 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. 0-day PHI.

**Omega 500F** at 0.75-1.5 pts. per acre. 30-day PHI.

**Orondis Ultra** at 4-8 fl. oz. per acre. 0-day PHI.

**Presidio** at 4 fl. oz. per acre. 2-day PHI.

**Previcur Flex** at 1.2 pts. per acre. 2-day PHI.

**Ranman** at 2.1-2.75 fl. oz. per acre. 0-day PHI.

**Revus 2.09SC** at 8 fl. oz. per acre. Suppression only. 0-day PHI.

**Tanos 50DF** at 8 oz. per acre. 3-day PHI.

**Zampro** at 14 fl. oz. per acre 0-day PHI.

**Zing 4.9SC** at 36 fl. oz. per acre. 0-day PHI.

**Fusarium Fruit Rot**

Pumpkin fruit are more likely than other cucurbits to be affected by Fusarium fruit rot. There are no symptoms on foliage. 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. Growing pumpkins in cover crops may help to lessen the disease. 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 and Phytophthora blight.

**Harvest:** Identify fruit problems.

**Gummy Stem Blight/Black Rot**

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. See Fungicide Resistance Management (page 76) for more information. 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.

**Harvest:** Identify fruit problems.

**Recommended Products**

**Bravo**, **Echo**, **Equus**, and **Initiate** are labeled for use at various rates. 0-day PHI.

**Dithane** and **Penncozeb** are labeled for use at various rates. 5-day PHI.

**Inspire Super** at 16-20 fl. oz. per acre. 7-day PHI.

**Luna Experience** at 10-17 fl. oz. per acre 7-day PHI.

**Monsoon** at 8 fl. oz. per acre. 7-day PHI.

**Switch** at 11-14 oz. per acre. 1-day PHI.

**Toledo** at 8 fl. oz. per acre. 7-day PHI.

**Vibe** at 8 fl. oz. per acre. 7-day PHI.

**Phytophthora Crown Rot, Fruit and Foliar Blight**

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.
Planting: Direct-seeded crops benefit from fungicide-treated seed. Treat seed with Apron XL LS® prevent Phytophthora infection for 5 weeks from time of seeding. Do not use contaminated water with Phytophthora. Ponds with run-off water from infested soil may be contaminated with Phytophthora. Use crop rotations of at least three years with non-cucurbits. Avoid rotating with peppers.

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.

Recommended Products
Apron XL LS® at 6.4 fl. oz. per 100 lbs. seed. Only for direct-seeded plants.
Forum 4.18SC® at 6 fl. oz. per acre. 0-day PHI.
Gavel 75DF® at 1.5-2.0 lbs. per acre. 5-day PHI.
Orondis Ultra® at 4-8 fl. oz. per acre. 0-day PHI.
Presidio 4SC® at 3-4 fl. oz. per acre. 2-day PHI.
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. 0-day PHI.

Ranman 400SC® at 2.75 fl. oz. per acre. 0-day PHI.
Revus 2.09SC® at 8 fl. oz. per acre. Suppression only. 0-day PHI.
Tanos 50WDG® at 8-10 oz. per acre. 3-day PHI.
Zampro® at 14 fl. oz. per acre. 0-day PHI.

Powdery Mildew
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.

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 first harvest.

Recommended Products
Aprovia Top® at 10.5-13.5 fl. oz. per acre. 0-day PHI.
Fontelis® at 12-16 fl. oz. per acre. 1-day PHI.
Inspire Super® at 16-20 fl. oz. per acre. 7-day PHI.
Luna Experience® at 6-17 fl. oz. per acre. 7-day PHI.
Luna Sensation® at 4-7.6 fl. oz. per acre. 0-day PHI.
Merivon® at 4-5.5 fl. oz per acre. 0-day PHI.
Microthiol 80DF® at 5-10 lbs. per acre. 0-day PHI.
Monsoon® at 6-8 fl. oz per acre. 7-day PHI.
Pristine 39WG® at 12.5-18.5 oz per acre. 0-day PHI.
Procure 50WS® at 4-8 oz. per acre. 0-day PHI.
Quintec® at 4-8 oz. per acre. May cause minor leaf yellowing. 3-day PHI.
Rally 40W® at 2.5-5.0 oz. per acre. 0-day PHI.
Toledo® at 8 fl. oz per acre. 7-day PHI.
Vive® at 8 fl. oz. per acre. 7-day PHI.
Vivando® at 15.4 fl. oz. per acre. Supplemental label required. 0-day PHI.

Plectosporium Blight
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.

Recommended Products
Cabrio® at 12-16 oz. per acre. 0-days PHI.
Flint® at 1.5-2.0 oz. per acre. 0-day PHI.
Inspire Super® at 16-20 fl. oz. per acre. 7-day PHI.
Quadris 2.08SC® at 11.0-15.4 fl. oz. per acre. 1-day PHI.

This is a reduced-risk pesticide. See page 37 for details.
Root Knot Nematodes
Winter/off-season: Root knot nematodes have a host range of more than 2,000 plants, so crops 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.

Recommended Products
InLine®. See label for rates.

Nimitz * at 3.5-5 pts. per acre. Do not use on direct-seeded plants. May be broadcast, banded, or drip-applied. 7-day plant back interval.

Telone II* or Telone C-35*. See labels for rates. RUP.

Vydate L® at 1-2 gals. per acre in 20 gals. of water broadcast. Incorporate 2-4 inches. RUP.

Vapam®. See label for rates.

Scab
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.

Virus Diseases: Cucumber Mosaic (CMV), Papaya Ring Spot (PRSV), Squash Mosaic (SqMV), Watermelon Mosaic (WMV), Zucchini Yellow Mosaic (ZYMV)
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.

Common Cucurbit Viruses and Transmission Sources

<table>
<thead>
<tr>
<th>Virus</th>
<th>Host Range</th>
<th>Transmission Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cucumber Mosaic Virus</td>
<td>wide</td>
<td>aphids^1</td>
</tr>
<tr>
<td>Papaya Ring Spot Virus</td>
<td>Cucurbitaceae</td>
<td>aphids^1</td>
</tr>
<tr>
<td>Squash Mosaic Virus</td>
<td>Cucurbitaceae, Chenopodiaceae</td>
<td>seeds, cucumber beetles</td>
</tr>
<tr>
<td>Watermelon Mosaic Virus</td>
<td>Cucurbitaceae, weeds</td>
<td>aphids^1</td>
</tr>
<tr>
<td>Zucchini Yellow Mosaic Virus</td>
<td>Cucurbitaceae</td>
<td>aphids^1</td>
</tr>
</tbody>
</table>

^1 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 for Squash and Pumpkin
For combined weed control options in cucurbits, see page 118.

Insect Control for Squash and Pumpkin
For combined insect control options in cucurbits, see page 122.
Cucurbit Crops — Cantaloupe, Cucumber, and Watermelon

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 pollinator variety for good fruit set. Pollinizers are usually included when you buy gynoecious seed. Parthenocarpic varieties will set fruit without pollination and no seeds will develop. Parthenocarpic varieties will produce seeds if they get pollinated.

Melon

Melons 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.

The most commonly cultivated melon is cantaloupe. Cantaloupes grown in the Midwest are primarily eastern types. Typical varieties include Athena and Aphrodite.

Melon types with distinctive fruit attributes are generally 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.

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 pollinator plants or seeded watermelons) next to the triploid plants. The general rule is to plant a pollinator 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.

Typically, seedless watermelons are no more than 12 pounds. They are sold in 800-pound cardboard bins with 60, 45, 36 and 30-count categories. 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. There also is a unique rind pattern called moon and star. It 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, there are yellow, orange and white-fleshed varieties available. Varieties include Orange Crisp (orange, seedless), Amarillo (yellow, seedless), and Cream of Saskatchewan (white, seeded).
Watermelon Variety Resistance to Fusarium Wilt

<table>
<thead>
<tr>
<th>Variety</th>
<th>Company</th>
<th>Type</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afternoon Delight</td>
<td>Dwayne Palmer</td>
<td>triploid</td>
<td>+1/2</td>
</tr>
<tr>
<td>Crunchy Red</td>
<td>Harris Moran</td>
<td>Triploid</td>
<td>++</td>
</tr>
<tr>
<td>Distinction</td>
<td>Syngenta seeds</td>
<td>Triploid</td>
<td>++++</td>
</tr>
<tr>
<td>Fascination</td>
<td>Syngenta Seeds</td>
<td>triploid</td>
<td>++++</td>
</tr>
<tr>
<td>Fiesta</td>
<td>Syngenta Seeds</td>
<td>diploid</td>
<td>++1/2</td>
</tr>
<tr>
<td>Indiana</td>
<td>Seedway</td>
<td>triploid</td>
<td>++</td>
</tr>
<tr>
<td>Liberty</td>
<td>triploid</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>Palomar</td>
<td>Syngenta Seeds</td>
<td>triploid</td>
<td>++</td>
</tr>
<tr>
<td>Matrix</td>
<td>triploid</td>
<td>+++1/2</td>
<td></td>
</tr>
<tr>
<td>Melody</td>
<td>triploid</td>
<td>+++</td>
<td></td>
</tr>
<tr>
<td>Regency</td>
<td>Seminis</td>
<td>diploid</td>
<td>++++</td>
</tr>
<tr>
<td>Revolution</td>
<td>triploid</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Royal Sweet</td>
<td>Seminis</td>
<td>diploid</td>
<td>++</td>
</tr>
<tr>
<td>Summer Sweet 5244</td>
<td>Abbott &amp; Cobb</td>
<td>triploid</td>
<td>++</td>
</tr>
<tr>
<td>Summer Sweet 7167</td>
<td>Abbott &amp; Cobb</td>
<td>triploid</td>
<td>+</td>
</tr>
<tr>
<td>SW 4502</td>
<td>Seedway</td>
<td>triploid</td>
<td>+1/2</td>
</tr>
<tr>
<td>Trillion</td>
<td>Abbott &amp; Cobb</td>
<td>triploid</td>
<td>+1/2</td>
</tr>
<tr>
<td>Triple Threat</td>
<td></td>
<td>triploid</td>
<td>+++</td>
</tr>
<tr>
<td>Tri-X-313</td>
<td>Syngenta Seeds</td>
<td>triploid</td>
<td>+1/2</td>
</tr>
<tr>
<td>Troubadour</td>
<td>Harris Moran</td>
<td>Triploid</td>
<td>+</td>
</tr>
<tr>
<td>Vagabond</td>
<td>triploid</td>
<td>+++1/2</td>
<td></td>
</tr>
</tbody>
</table>

1 Inclusion of these varieties does not imply endorsement or criticism of any variety or company. Refer to company literature for information on host resistance claims.

2 The resistance ratings provided here are averages based on several years of greenhouse research. In that research, each watermelon variety was observed after receiving an artificial inoculation with a race 1 strain of the disease. ++++ = good resistance; +++ = moderate resistance; ++ = some resistance; + = little or no resistance.

3 OP=open pollinated variety included for comparison.

Pollenizer Watermelon Resistance to Fusarium Wilt

<table>
<thead>
<tr>
<th>Variety</th>
<th>Type</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ace</td>
<td>pollenizer</td>
<td>+</td>
</tr>
<tr>
<td>Companion</td>
<td>pollenizer</td>
<td>++++1/2</td>
</tr>
<tr>
<td>Jenny</td>
<td>pollenizer/edible</td>
<td>+1/2</td>
</tr>
<tr>
<td>Mickey Lee</td>
<td>pollenizer/edible</td>
<td>+++1/2</td>
</tr>
<tr>
<td>Pinnacle</td>
<td>pollenizer</td>
<td>+1/2</td>
</tr>
<tr>
<td>Polimax 6017</td>
<td>pollenizer</td>
<td>+</td>
</tr>
<tr>
<td>Sidekick</td>
<td>pollenizer</td>
<td>++++1/2</td>
</tr>
<tr>
<td>SP-5</td>
<td>pollenizer</td>
<td>+++</td>
</tr>
<tr>
<td>Regency</td>
<td>pollenizer/edible</td>
<td>+++</td>
</tr>
</tbody>
</table>

1 The resistance ratings provided here are averages based on several years of greenhouse and field research. In the greenhouse research, each watermelon variety was observed after receiving an artificial inoculation with a race 1 strain of the disease. ++++ = good resistance; +++ = moderate resistance; ++ = some resistance; + = little or no resistance.

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 since 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) will result 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 will 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 being used, cucumbers should be harvested at 2 to 4 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.

You should harvest cantaloupe that has a long shelf life when vertical cracks appear on the peduncle; do not wait until such cantaloupe slip.
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.

### Disease Management with the MELCAST System

MELCAST is a disease warning system that can help Indiana farmers schedule their fungicide applications for control of certain diseases of watermelons and cantaloupes. See Disease Forecasting Systems (page 77) for details.

### Disease Control for Cantaloupe, Cucumber, and Watermelon

#### Alternaria Leaf Blight

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.

**Harvest:** Fungicide applications are unnecessary within 2-3 weeks of final harvest.

#### Recommended Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aprovia Top*</td>
<td>at 10.5-13.5 fl. oz. per acre 0-day PHI.</td>
</tr>
<tr>
<td>Bravo*, Echo*, Equus*, and Initiate*</td>
<td>are labeled for use at various rates. 0-day PHI.</td>
</tr>
<tr>
<td>Cabrio EG*</td>
<td>at 12-16 oz. per acre. See label to avoid practices that could result in crop injury. See label for tank-mix caution. 0-day PHI.</td>
</tr>
<tr>
<td>Dithane*, Manzate*, and Pencozeb*</td>
<td>are available for use at various rates. 5-day PHI.</td>
</tr>
<tr>
<td>Fontelis*</td>
<td>at 12-16 fl. oz. per acre. See label for greenhouse uses. 1-day PHI.</td>
</tr>
<tr>
<td>Gavel 75DF*</td>
<td>at 1.5-2 lbs. per acre. 5-day PHI.</td>
</tr>
<tr>
<td>Inspire Super*</td>
<td>at 16-20 fl. oz. per acre. 7-day PHI.</td>
</tr>
<tr>
<td>Luna Experience*</td>
<td>at 8-17 fl. oz. per acre. 7-day PHI.</td>
</tr>
<tr>
<td>Luna Sensation*</td>
<td>at 7.6 fl. oz. per acre. 0-day PHI.</td>
</tr>
<tr>
<td>Merivon*</td>
<td>at 4-5.5 fl. oz. per acre. 0-day PHI.</td>
</tr>
<tr>
<td>Pristine 38WG*</td>
<td>at 12.5-18.5 oz. per acre. 0-day PHI.</td>
</tr>
<tr>
<td>Quadris 2.08SC*</td>
<td>at 11.0-15.5 fl. oz. per acre. 1-day PHI.</td>
</tr>
<tr>
<td>Quadris Opti*</td>
<td>at 3.2 pts. per acre. 1-day PHI.</td>
</tr>
<tr>
<td>Satori*</td>
<td>at 11-15.5 fl. oz. per acre.</td>
</tr>
<tr>
<td>Switch 62.5WG*</td>
<td>at 11-14 oz. per acre. 1-day PHI.</td>
</tr>
<tr>
<td>Tanos 50WG*</td>
<td>at 8 oz. per acre. 3-day PHI.</td>
</tr>
<tr>
<td>Zing 4.9SC*</td>
<td>at 36 fl. oz. per acre. 0-day PHI.</td>
</tr>
</tbody>
</table>

#### Angular Leaf Spot

Angular leaf spot is normally restricted to the spring or early summer. Angular leaf spot may be transmitted via seed.

Dithane* and Manzate* may help manage angular leaf spot when used with fixed copper products.

#### Anthracnose

Race 1 of the fungal pathogen that causes anthracnose affects mainly cucumber — some 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.

**Harvest:** Inspect fruit. Avoid saving seed.

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*This is a reduced-risk pesticide. See page 37 for details.*
**Recommended Products**

**Aprovia Top** at 10.5-13.5 fl. oz. per acre 0-day PHI.

**Bravo**, **Echo**, **Equus**, and **Initiate** are labeled for use at various rates. 0-day PHI.

**Cabrio EG** at 12-16 oz. per acre. See warnings under Alternaria leaf blight. 0-Day PHI.

**Dithane**, **Manzate**, and **Penncozeb** are available for use at various rates. 5-day PHI.

**Inspire Super** at 16-20 fl. oz. per acre. 7-day PHI.

**Luna Experience** at 10-17 fl. oz. per acre. 7-day PHI.

**Luna Sensation** at 7.6 fl. oz. per acre. 0-day PHI.

**Merivon** at 4-5.5 fl. oz. per acre. 0-day PHI.

**Pristine 38WG** at 18.5 oz. per acre. 0-day PHI.

**Quadris 2.08SC** at 11-15.4 fl. oz. per acre. 1-day PHI.

**Quadris Opti** 3.2 pts. per acre 1-day PHI.

**Tanos 50WG** at 8 oz. per acre. 3-day PHI.

**Topsin 4.5L** at 10 fl. oz. per acre. 1-day PHI.

**Topsin WSB** at 0.5 lb. per acre. 1-day PHI.

**Zing 4.9SC** at 36 fl. oz. per acre. 0-day PHI.

**Bacterial Fruit Blotch**

The occurrence of bacterial fruit blotch (BFB) is highly correlated with seed contaminated with the causal bacterium. BFB symptoms may occur on leaves in the transplant greenhouse or in the field where they may be easily overlooked. However, only lesions on mature fruit are of economic importance. The pathogen is primarily seedborne (introduced with contaminated seed), but may overwinter on crop debris in greenhouses and in the field.

Many cucurbit crops may be affected, but bacterial fruit blotch is most often observed on watermelon and cantaloupe.

Winter/Off-season: Fall-plow contaminated fields and plant to crops other than cucurbits for at least 2 years. Subsequent grain crops are suggested for the rotation so that broadleaf herbicides will kill volunteer seedlings in the spring. Purchase seed tested for BFB.

Greenhouse: Scout and apply fixed copper if disease threatens. Sanitize greenhouse thoroughly after each generation of transplants.

Planting: Avoid planting diseased seedlings.

Vine Touch: Fixed copper compounds may lessen the impact of the disease.

Harvest: Inspect fruit. Avoid saving seed.

**Recommended Products**

**Actigard** at 0.5-1 oz. per acre. Apply with two of the fixed copper product applications described below. 0-day PHI.

In situations where fruit blotch threatens, apply copper products as outlined below to help reduce the rate of disease spread.

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 bloom, and 2 weeks after the first female bloom. No more than 6 applications per season.

**Bacterial Wilt**

Bacterial wilt primarily affects cantaloupe and cucumber. Striped or spotted cucumber beetle feeding from the seedling stage until shortly after vine touch spreads the causal bacterium from plant to plant. Symptom expression may not occur until cantaloupe fruit near maturity, at which point it is too late to stop the spread of the disease.

Winter/Off-season: The disease is unaffected by crop rotation.

Planting: Apply systemic insecticides such as Admire® or Platinum® (see insect section). Apply contact insecticides after systemic insecticides lose effectiveness (2-3 weeks). Apply insecticides only when beetles are present. When large numbers are present, treatments may be required twice weekly. Scout fields regularly for cucumber beetles.

**Damping-off**

Practice good greenhouse sanitation. The best way to prevent damping-off of seedlings in the greenhouse is to keep the greenhouse area clean. See 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.

**Recommended Products**

**Previcur Flex**. See label for details about for managing damping-off caused by Pythium species.

**Ridomil Gold SL** at 1-2 pts. per acre. For damping-off caused by Pythium.

**Downy Mildew**

The downy mildew pathogen does not survive in the Midwest, so it usually arrives in the Midwest via the wind. Downy mildew may not occur in the Midwest until August or September and in some years, does not occur in the Midwest at all.
Strains of the downy mildew fungus 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 susceptible to resistance. See Fungicide Resistance Management (page 76) for more information.

**Winter/Off-season:** The disease is unaffected by crop rotation.

**Planting:** Begin scouting in July. Follow disease progress in the Purdue Extension Vegetable Crops Hotline bulletin or at cdm.ipmPIPE.org. Apply systemic downy mildew fungicides only if disease is observed in the area.

**Recommended Products**

- **Aprovia Top®** at 10.5-13.5 fl. oz. per acre 0-day PHI.
- **Bravo®, Echo®, Equus®, and Initiate®** are labeled for use at various rates. 0-day PHI.
- **Catamaran®** at 6 pts. per acre. 1-day PHI.
- **Mancozeb** products (including Dithane®, Manzate®) are labeled at various rates. Some mancozeb formulations may not be labeled for pumpkin. 5-day PHI.
- Several phosphite or phosphorous acid products are labeled at various rates (including Agri-Fos®, Phostrol®, Prophyt®, 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 Phytophthora blight is observed. 0-day PHI.
- **Omega 500F®** at 0.75-1.5 pts. per acre. 30-day PHI.
- **Orondis Opti®**, Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack. 0-day PHI.
- **Orondis Ridomil Gold SL®**, Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack to soil only. 5-day PHI.
- **Orondis Ultra®**, Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack. 0-day PHI.
- **Presidio®** at 3-4 fl. oz. per acre. 2-day PHI.
- **Previcur Flex®** at 1.2 pts. per acre. 2-day PHI.
- **Ranman®** at 2.1-2.75 lbs. per acre. 0-day PHI.

**Fusarium Fruit Rot**

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.

**Fusarium Wilt in Cantaloupe**

Plant resistant cantaloupe cultivars. Several cultivars have good resistance to strains of Fusarium found in Indiana and Illinois.

**Fusarium Wilt in Watermelon**

Plant watermelon cultivars with partial resistance. See table on page 110. Rotate with noncucurbit crops to decrease incidence of wilt.

**Recommended Products**

- **Proline®** at 5.7 fl. oz. per acre. May be applied by ground or chemigation application equipment. Do not use in water used for hand transplanting. 7-day PHI.

**Gummy Stem Blight/Black Rot**

Gummy stem blight may occur on transplants in the greenhouse through harvest. The leaves and stems of cantaloupe and watermelon may be affected. Occasionally, fruit are affected, which is known as black rot.

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®) and fungicides with the active ingredient boscalid Group 7 (such as Fontelis®, Merivon®, Pristine®) are particularly susceptible to resistance. See Fungicide Resistance Management (page 76) for more information. 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.

Harvest: Identify fruit problems.

**Recommended Products**

**Aprovia Top®** at 10.5-13.5 fl. oz. per acre 0-day PHI.

**Bravo®, Echo®, Equus®, and Initiate®** are labeled for use at various rates. 0-day PHI.

**Dithane®** and **Penncozeb®** are labeled for use at various rates. 5-day PHI.

**Fontelis®** at 12-16 fl. oz. per acre. 1-day PHI.

**Luna Experience®** at 10-17 fl. oz. per acre. 7-day PHI.

**Monsoon®** at 8 fl. oz. per acre. 7-day PHI.

**Switch®** at 11-14 oz. per acre. 1-day PHI.

**Toledo®** at 8 fl. oz. per acre. 7-day PHI.

**Vibe®** at 8 fl. oz. per acre. 7-day PHI.

**Phytophthora Root Rot and Foliar Blight**

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 may benefit from fungicide-treated seed.

**Vine Touch**: Apply contact or systemic fungicides at first sign of disease. Some systemic fungicides are available.

**Harvest**: Identify fruit problems.

**Recommended Products**

**Aprovia Top®** at 13.5-15.5 fl. oz. per acre. 0-day PHI.

**Fontelis 1.67SC®** at 12-16 fl. oz. See label for greenhouse uses. 1-day PHI.

**Luna Experience®** at 6-17 fl. oz. per acre. 7-day PHI.

**Luna Sensation®** at 4-7.6 fl. oz. per acre. 0-day PHI.

**Inspire Super®** at 16-20 fl. oz. per acre. 7-day PHI.

**Merivon®** at 4-5.5 fl. oz. per acre. 0-day PHI.

**Orondis Ridomil Gold SL®**: Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack to soil only. 5-day PHI.

**Orondis Ultra®**: Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack. 0-day PHI.

**Presidio 4SC®** at 4 fl. oz. per acre. 2-day PHI.

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. 0-day PHI.

**Ranman®** at 2.75 lbs. per acre. 0-day PHI.

**Revus 2.09SC®** at 8 fl. oz. per acre. Suppression only. 0-day PHI.

**Tanor®** at 8-10 oz. per acre. 3-day PHI.

**Zampro®** at 14 fl. oz. per acre. 0-day PHI.

**Powdery Mildew**

Many cucumber and cantaloupe varieties have good resistance to powdery mildew. Watermelon usually are not affected by powdery mildew in the Midwest. This disease does not require leaf wetness for disease initiation or spread.

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®, Merivon®, Quadris®, Satori®, and Topsin®. Alternate fungicides between MOA groups.

**Winter/Off-season**: Crop rotation and fall tillage are moderately important. Resistant or partially resistant cantaloupe cultivars are available.

**Vine Touch**: Begin systemic fungicide applications 7-14 days before harvest (cantaloupe).

**Recommended Products**

**Aprovia Top®** at 13.5-15.5 fl. oz. per acre. 0-day PHI.

**Fontelis 1.67SC®** at 12-16 fl. oz. See label for greenhouse uses. 1-day PHI.

**Luna Experience®** at 6-17 fl. oz. per acre. 7-day PHI.

**Luna Sensation®** at 4-7.6 fl. oz. per acre. 0-day PHI.

**Inspire Super®** at 16-20 fl. oz. per acre. 7-day PHI.

**Merivon®** at 4-5.5 fl. oz. per acre. 0-day PHI.
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.

Microthiol 80DF® at 5-10 lbs. per acre, or other sulfur formulations. 0-day PHI.

Monsoon® at 8 fl. oz. per acre. 7-day PHI.

Pristine® at 12.5-18.5 oz. per acre. 0-day PHI.

Procure 50WS® at 4-8 oz. per acre. 0-day PHI.

Quintec® at 4-6 fl. oz. per acre. Not for cucumber. 3-day PHI.

Rally 40W® at 2.5-5.0 oz. per acre. 0-day PHI.

Torino® at 3.4 oz. per acre. 0-day PHI.

Vivando® at 15.4 fl. oz. per acre. Must be in possession of supplemental label. 0-day PHI.

**Root Knot Nematodes**

**Winter/off-season:** Root knot nematodes have a host range of more than 2,000 plants, so crops 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.

**Recommended Products**

InLine® See label for rates.

Nimitz® at 3.5-5 pts. per acre. Do not use on direct-seeded plants. May be broadcast, banded, or drip applied. 7-day plant back interval.

Telone II® or Telone C-35® See labels for rates. RUP.

Vydate L® at 1-2 gals. per acre in 20 gals. of water broadcast. Incorporate 2-4 inches. RUP.

Vapam® See label for rates.

**Scab**

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. Many cucumber varieties have resistance. 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.

**Virus Diseases:** Cucumber Mosaic Virus (CMV), Zucchini Yellow Mosaic Virus (ZYMV), Watermelon Mosaic Virus (WMV)

Aphids transmit virus diseases, including cucumber mosaic virus, papaya ring spot virus, watermelon mosaic virus, and zucchini yellow mosaic virus. All varieties are susceptible to these viruses.

It may help to (1) kill perennial weeds (virus source plants) within 150 feet of planting and (2) control aphids (virus carriers). Resistant varieties are not yet available.

Early planting and development of pumpkins and squash before virus diseases become prevalent may reduce disease severity.

**Planting:** Earlier planted or earlier maturing pumpkin cultivars will help to avoid severe disease problems.

**Vine Touch:** Control weeds in and around production area.

<table>
<thead>
<tr>
<th>Virus</th>
<th>Host Range</th>
<th>Transmission Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cucumber Mosaic Virus</td>
<td>wide</td>
<td>aphids&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Papaya Ring Spot Virus</td>
<td>Cucurbitaceae</td>
<td>aphids&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Squash Mosaic Virus</td>
<td>Cucurbitaceae, Chenopodiaceae</td>
<td>seeds, cucumber beetles</td>
</tr>
<tr>
<td>Watermelon Mosaic Virus</td>
<td>Cucurbitaceae, weeds</td>
<td>aphids&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Zucchini Yellow Mosaic Virus</td>
<td>Cucurbitaceae</td>
<td>aphids&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<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.
## Product/Disease Ratings for All Cucurbits

<table>
<thead>
<tr>
<th>Product (REI/PHI)&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Common name</th>
<th>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.</th>
<th>Alternaria leaf blight</th>
<th>Anthracnose</th>
<th>Bacterial fruit blotch</th>
<th>Bacterial fruit spot</th>
<th>Downy mildew</th>
<th>Gummy stem blight/black rot</th>
<th>Plectosporium blight</th>
<th>Phytophthora blight</th>
<th>Powdery mildew</th>
<th>Use</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actigard® (12/0)</td>
<td>acibenzolar-S-methyl (21)</td>
<td>F P P P P P</td>
<td>Use with copper applications for bacterial fruit blotch (see page 113).</td>
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</tr>
<tr>
<td>Agri-Fos®, Phostrol®, Prophyt®, Rampart® (4/0)</td>
<td>phosphorus acid/phosphite (33)</td>
<td>F F F</td>
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<tr>
<td>Aliette® 12/1/2</td>
<td>fosetyl-Al (33)</td>
<td>P P P</td>
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<tr>
<td>Aprovia Top (12/0)</td>
<td>difenconazole (3), benzovindiflupyr (7)</td>
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<tr>
<td>Bravo®, Echo®, Equus®, Initiate® (12/0)</td>
<td>chlorothalonil (M)</td>
<td>G G F G P F G</td>
<td>There may be resistance issues with downy mildew and gummy stem blight.</td>
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<td>Cabrio® (12/0)</td>
<td>pyraclostrobin (11)</td>
<td>G G P P G F</td>
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<tr>
<td>copper (active ingredient) (24/0)</td>
<td>copper (M)</td>
<td>P P F P P P</td>
<td>There may be resistance issues with powdery mildew.</td>
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<tr>
<td>Dithane®, Manzate®, Penncozeb® (24/5)</td>
<td>mancozeb (M)</td>
<td>G G F G G G</td>
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<td>Flint® (12/0)</td>
<td>trifloxystrobin (11)</td>
<td>P F P P</td>
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<tr>
<td>Fontelis® (12/1)</td>
<td>penthiopyrad (7)</td>
<td>G P P</td>
<td>There may be resistance issues with powdery mildew.</td>
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<tr>
<td>Forum 4.18SC® (12/0)</td>
<td>dimethomorph (40)</td>
<td>G G G</td>
<td>Do not alternate with Revus®.</td>
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<tr>
<td>Gavel® (48/5)</td>
<td>mancozeb (M), zoxamide (22)</td>
<td>G G F</td>
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<tr>
<td>Inspire Super® (12/7)</td>
<td>difenoconazole (3), cyprodinil (9)</td>
<td>G G G G F</td>
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<tr>
<td>Luna Experience® (12/7)</td>
<td>fluopyram (7), tebuconazole (3)</td>
<td>G F G G</td>
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<tr>
<td>Luna Sensation® (12/0)</td>
<td>trifloxystrobin (11), fluopyram (7)</td>
<td>G G F</td>
<td>Watermelon only.</td>
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<tr>
<td>Merivon® (12/0)</td>
<td>fluxapyroxad (7), pyraclostrobin (11)</td>
<td>G G P P G</td>
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<tr>
<td>Monsoon®, Onset®, Toledo®, Vibe® (12/7)</td>
<td>tebuconazole (3)</td>
<td>G F</td>
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<tr>
<td>Orondis Opti® (4/0)</td>
<td>oxathiapiprolin (U15), chlorothalonil (M)</td>
<td>G G G</td>
<td>Apply as tank-mix of both products in multi-pack.</td>
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<tr>
<td>Orondis Ridomil Gold SL® (48/5)</td>
<td>oxathiapiprolin (U15), mefenoxam (4)</td>
<td>G G G</td>
<td>Apply as tank-mix of both products in multi-pack to soil.</td>
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<tr>
<td>Orondis Ultra® (4/0)</td>
<td>oxathiapiprolin (U15), mandipropamid (40)</td>
<td>G G G</td>
<td>Apply as tank-mix of both products in multi-pack.</td>
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<tr>
<td>Presidio 4SC® (12/2)</td>
<td>fluopicolide (43)</td>
<td>G G G</td>
<td>Primary use will be for Phytophthora blight in rotation with Revus®.</td>
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<tr>
<td>Previcur Flex® (12/2)</td>
<td>propamocarb (28)</td>
<td>F</td>
<td>Has greenhouse label for damping-off.</td>
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<tr>
<td>Pristine® (12/0)</td>
<td>boscalid (7), pyraclostrobin (11)</td>
<td>G G P P P</td>
<td>There may be resistance issues with downy mildew and gummy stem blight.</td>
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<tr>
<td>Procure® (12/0)</td>
<td>triflumizole (3)</td>
<td>G</td>
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<tr>
<td>Quadris®, Satori® (4/1)</td>
<td>azoxystrobin (11)</td>
<td>G G P P G F</td>
<td>There may be resistance issues with downy mildew and gummy stem blight.</td>
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<tr>
<td>Quadris Opti® (12/1)</td>
<td>azoxystrobin (11), chlorothalonil (M)</td>
<td>G G P P F</td>
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<tr>
<td>Quintec® (12/3)</td>
<td>quinoxyfen (13)</td>
<td>G</td>
<td>Contact fungicide with single mode of action</td>
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<tr>
<td>Rally® (24/0)</td>
<td>mycolbutanil (3)</td>
<td>G</td>
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<tr>
<td>Ramman® (12/0)</td>
<td>cyazofamid (21)</td>
<td>G G</td>
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<tr>
<td>Revus® (4/0)</td>
<td>mandipropamid (40)</td>
<td>S S</td>
<td>Primary use will be for Phytophthora blight in rotation with Presidio®.</td>
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<tr>
<td>Switch 62.5WB® (12/1)</td>
<td>cyprodinil (9), fludioxanil (12)</td>
<td>G G G G</td>
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<tr>
<td>Tanos® (12/3)</td>
<td>cymoxanil (27), farnamoxadone (11)</td>
<td>G G S F S</td>
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<td>Topsis M® (12/0)</td>
<td>thiophanate-methyl (1)</td>
<td>G F P</td>
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<tr>
<td>Torino® (4/0)</td>
<td>cyflufenamid (U6)</td>
<td>G</td>
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<tr>
<td>Vivando® (12/0)</td>
<td>metrafenid (U8)</td>
<td>G</td>
<td>Must be in possession of supplemental label.</td>
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<tr>
<td>Zampro® (12/0)</td>
<td>ametocetrin (45), dimethomorph (40)</td>
<td>G G</td>
<td>See label for directions for at planting drench.</td>
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<td>Zing® (12/0)</td>
<td>zoxamide (22), chlorothalonil (M)</td>
<td>G G F</td>
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</table>

<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.
Weed Control for All Cucurbits

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 premergence 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.

For specific weeds controlled by each herbicide, check Table 25 on page 66.
**Preemergence Broadleaves and Grasses**

**Recommended Products**

**Command 3ME** at the following rates:

- **Cantaloupe and watermelon in Indiana, Michigan and Ohio only**: 0.67-1.27 pts. 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 between rows. There is less risk of crop injury if applied between rows, and if melons are transplanted rather than seeded. Do not exceed 1.27 pts. per acre or 1 application per crop per season. 60-day PHI.

- **Cucumber in Indiana, Michigan, and Ohio only**: 0.67-1 pt. per acre. Apply after seeding before weeds or crop emerge. Use lower rates on coarse soils. **Direct-seeded crops**: 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. 60-day PHI.

- **Pumpkin**: 1-1.33 pts. per acre to row-middles only: 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. 30-day PHI.

- **Winter squash in Indiana, Michigan, and Ohio only**: 1-1.3 pts. per acre. Apply after seeding before weeds or crop emerge. Injury to winter squash may occur if applied directly over the planted row or hill. Consider leaving an untreated strip directly over seed. Do not exceed 1.3 pt. per acre per crop. 30-day PHI.

**Prowl H2O** at 2.1 pts. per acre. **Cantaloupe and watermelon only**: 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 pts. per acre per application or 4.2 pts. per acre per season. 35-day PHI.

**Sinbar** at 2-4 oz. per acre. **Watermelons only**: Do not use on sand or gravel soils. Not recommended on soils with less than 1% organic matter due to crop injury potential. Apply pre-transplant to bare ground, or pre-transplant under plastic mulch, or to row middles. For direct-seeded crops on bare ground, apply after planting before crop emerges. Do not allow spray to contact crop. 70-day PHI. Do not plant other crops within 2 years of application.

**Strategy** at 2-6 pts. per acre. **Strategy** is a premix containing the active ingredients of Command and Curbit. **Direct-seeded crops**: 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. 45-day PHI for cucumbers and squash.

**Trifluralin** products at 1-2 pts. per acre. Use 4EC formulations at 1-2 pts. per acre. Use lowest rate on coarse soils. Apply as a directed spray between rows after plants have 3-4 leaves and incorporate. 60-day PHI for watermelon. 30-day PHI for all others.

**Preemergence Broadleaves**

**Recommended Products**

**League** at 4-6.4 oz. per acre. **Cantaloupe and watermelon only; not for cucumber, squash, or pumpkin**: Use the higher rate in fields with a known history of 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 Valent-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. 48-day PHI.

Winter squash in Indiana, Michigan, and Ohio only: 1-1.3 pts. per acre. Apply after seeding before weeds or crop emerge. Injury to winter squash may occur if applied directly over the planted row or hill. Consider leaving an untreated strip directly over seed. Do not exceed 1.3 pt. per acre per crop. 30-day PHI.
Reflex® at 0.5-1 pt per acre. Pumpkin and winter squash only in Michigan and Illinois. Growers in Michigan must have a 24(c) label. Apply after seeding pumpkin or winter squash. Use in tank mix with other preemergent herbicides. Apply up to 7 days before transplanting pumpkin or squash. Use only once in 2 years on same soil. See label for rotation restrictions. 32-day PHI.

Sandea® at the following rates:

Direct-seeded pumpkins and winter squash on bare ground: 0.5-0.75 oz. per acre.

Direct-seeded cucumber, cantaloupe, and processing pumpkin on bare ground: 0.5-1 oz. per acre. Apply after seeding but prior to cracking.

Pretransplant cucumber, cantaloupe, pumpkin, and winter squash: 0.5-0.75 oz. per acre.

Pretransplant cucumber and cantaloupe: up to 1 oz. per acre. Apply to soil surface after final soil preparation or bed shaping and just before applying plastic mulch. Wait 7 days after application and mulch laying before transplanting.

Preemergence and pretransplant applications are allowed on watermelon in Indiana, Illinois, Kansas, and Missouri.

**Preemergence Grasses**

**Recommended Products**

Dacthal W-75® at 6-14 lbs. per acre, or Dacthal Flow-able® at 6-14 pts. per acre. Cantaloupe and watermelon only. 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.

Prefar 4E® at 5-6 qts. 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.

**Postemergence Broadleaves**

**Recommended Products**

Aim EC®. See details for Burndown or Directed/Shielded Application Broadleaves.

League®. See details above for Preemergence. Also controls nutsedge.

Sandea® at the following rates:

Pumpkin and winter squash on bare ground: 0.5-0.67 oz. per acre.

Cucumber, cantaloupe, and processing pumpkin on bare ground: 0.5-1 oz. per acre.

Not for for summer squash or watermelon on bare ground. For crops on plastic mulch, see details under Burndown or Directed/Shielded Application Broadleaves. Apply after the crop has 3-5 true leaves and is actively growing but before female flowers open. 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. Not recommended for use under cool temperatures due to potential for crop injury. May delay crop maturity. Do not exceed 2 applications per crop cycle. 30-day PHI for cucumber, squash, and pumpkin. 57-day PHI for cantaloupe.

**Postemergence Grasses**

**Recommended Products**

Poast 1.5E® at 1-1.5 pts. per acre. Use with 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 3 pts. per acre per season. 14-day PHI.

Select Max® at 9-16 fl. oz. per acre, or 2EC formulations of clethodim products at 6-8 fl. oz. per acre. Use low rates for annual grasses. Use high rates for perennial grasses. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Use 2EC formulations with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 64 fl. oz. of Select Max® per acre per season. Do not exceed 32 fl. oz. of 2EC formulations per acre per season. 14-day PHI.
# Herbicides for All Cucurbits

<table>
<thead>
<tr>
<th>Product (REI/PHI)</th>
<th>Common Name</th>
<th>Timing and Application Location Relative to Crop</th>
<th>Timing Relative to Weeds</th>
<th>Weed Groups Controlled</th>
<th>Crops</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Before seeding</td>
<td>After seeding before emergence</td>
<td>Before transplanting</td>
<td>Post emergence - between rows only</td>
</tr>
<tr>
<td>Aim EC® (12h/-)</td>
<td>carfentrazone</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Command 3ME® (12h/45d)</td>
<td>clomazone</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Curbit 3EC® (24h/-)</td>
<td>ethalfluralin</td>
<td>X</td>
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<tr>
<td>Dacthal W-75®, Dacthal Flowable® (12h/-)</td>
<td>DCPA</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Dual Magnum® (24h/30d)</td>
<td>s-metolachlor</td>
<td>X between rows</td>
<td>X between rows</td>
<td>X between rows</td>
<td>X</td>
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<tr>
<td>Gramoxone Inteon 2L® (12h to 24h/-)</td>
<td>paraquat</td>
<td>X</td>
<td>X</td>
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<tr>
<td>League® (12h/48d)</td>
<td>imazosulfuron</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Poast® (12h/14d)</td>
<td>sethoxydim</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>Prefar 4E® (12h/-)</td>
<td>bensulide</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>Roundup®, others (12h/14d)</td>
<td>pendimethalin</td>
<td>X between rows</td>
<td>X between rows</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sandea® (12h/30d to 57d)</td>
<td>halosulfuron</td>
<td>X</td>
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<tr>
<td>Select Max®, others (12h/14d)</td>
<td>clethodim</td>
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<td>Sinbar® (12h/70d)</td>
<td>terbacil</td>
<td>X</td>
<td>X</td>
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<td>Strategy® (24h/ 45d)</td>
<td>clomazone and ethalfluralin</td>
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<tr>
<td>Treflan®, others (12h/30d to 60d)</td>
<td>trifluralin</td>
<td>X</td>
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</table>

1For effectiveness against specific weeds, see Table 25 on page 66, 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.

2X=permitted for at least one crop.

3X=may be used for that crop. *=Processing crops only.
Insect Control for All Cucurbits

Seedcorn Maggots and Cucumber Beetles (in seed beds)
Treat seeds with a combination fungicide/insecticide, such as FarMore FI400®. Early clean plowing of cover crops will generally result in less damage to seedling plants in the field.

Seedcorn Maggot and Wireworm
Recommended Products
Capture LFR® at 0.39-0.49 fl. oz. per 1,000 linear ft. of row. Wireworms only. See label. RUP.

Aphids and Leafhoppers
Conserve natural enemies: limiting insecticide use will conserve predators and parasites that help control aphid populations. Monitor: look for the presence of predators or parasitized aphids. Several predators per aphid colony will probably bring the aphid population under control without insecticide. Killing aphids with insecticides cannot prevent the virus diseases they carry.

Recommended Products
Actara® (25WDG) at 1.5-3 oz. per acre. Aphids only. Do not exceed 11 oz. per acre per season. See pollinator precautions. 0-day PHI.
Admire PRO® (4.6DF) at 7.0-10.5 fl. oz. per acre. Apply pre-plant in a band 2 inches or less, as an in-furrow spray at planting, as a post-plant drench, as a sidedress application, or through trickle irrigation water. Do not exceed 10.5 fl. oz. per acre per season. See pollinator precautions. 21-day PHI.
Asana XL® (1.6) at 5.8-9.6 fl. oz. per acre. Leafhoppers only. Do not exceed 48 fl. oz. per acre per season. 3-day PHI. RUP.
Assail 30SG® at 2.5-4 oz. per acre. Do not exceed 5 applications per season. 0-day PHI.
Baythroid XL® (1EC) at 0.8-1.6 fl. oz. per acre. Potato leafhoppers only. Do not exceed 11.2 fl. oz. or 4 applications per acre per season. Allow 7 days between applications. 0-day PHI. RUP.
Belay 2.13SC® at 3-4 fl. oz. per acre. Do not apply during bloom. 7-day PHI.
Beleaf 50SG® at 2-2.8 oz. per acre. Aphids only. 0-day PHI.
Brigade® (2EC) at 2.6-6.4 fl. oz. per acre (do not exceed 19.2 fl. oz. per acre per season), or Brigade® (WSB) at 8-16 oz. per acre (do not exceed 48 oz. per acre per season). Leafhoppers only. 3-day PHI. RUP.

Dimethoate 400® or Dimethoate 4E® at 0.5-1 pt. per acre, or Dimethoate 2.67EC® at 0.75-1.5 pts. per acre. Cantaloupe and watermelon only. 3-day PHI.
Exirel® (0.83E) at 13.5-20.5 fl. oz. per acre. Aphids only. Do not exceed 61 fl. oz. per acre per season. See pollinator precautions. 1-day PHI.
Fulfill® (50WDG) at 2.75 oz. per acre. Aphids only. Do not exceed 5.5 oz. per acre per season. 0-day PHI.
Lannate SP® at 0.5-1 lb. per acre. Aphids only. Not for pumpkin or winter squash. 1-day PHI for applications of 0.5 lb. 3-day PHI for applications of more than 0.5 lb. RUP.
Malathion 5EC® at 1.5-2.8 pts. per acre, or Malathion 57EC® at 1.5 pts. per acre. Aphids only. 1-day PHI.
M-Pede® at 1-2% by volume. Aphids only. Must contact aphids to be effective. 0-day PHI.
Platinum® at 5-11 fl. oz. per acre. Do not exceed 11 fl. oz. per acre per season. 30-day PHI.
Pounce 25WP® at 12.8 oz. per acre, or Ambush 2EC® at 6.4-12.8 fl. oz. per acre. Leafhoppers only. 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 1.6 lbs. a.i. per acre per season. 0-day PHI. RUP.
Sivanto® (200SL) at the following rates:
Soil application: 21-28 fl. oz. per acre. 21-day PHI.
Foliar application: 7-12 fl. oz. per acre. 1-day PHI.
Venom® (70SG) at the following rates:
Foliar application: 1-4 oz. per acre. Do not exceed 6 oz. per acre per season. 1-day PHI.
Soil application: 5-7.5 oz. per acre. Do not exceed 12 oz. per acre per season. 21-day PHI.
Verimark 1.67SC® at 10-13.5 fl. oz. per acre via drip irrigation or soil injection. 1-day PHI.
Warrior II® at 1.28-1.92 fl. oz. per acre. Do not exceed 11.5 fl. oz. per acre per season. 1-day PHI. RUP.

Cucumber Beetles only (preplant)
Recommended Products
Admire PRO® (4.6F) at 7.0-10.5 fl. oz. per acre. Apply pre-plant in a band 2 inches or smaller, as an in-furrow spray at planting, as a post-plant drench, as a sidedress application, or through trickle irrigation water. Do not exceed 24 fl. oz. per acre per season. See pollinator precautions. 21-day PHI.
Platinum® at 5-11 fl. oz. per acre. 30-day PHI.
**Cucumber Beetles, Squash Bugs, and Squash Vine Borers**

Cantaloupe growers may consider using unbaited AM Yellow Sticky Traps for sampling cucumber beetles. Monitor fields frequently (2-3 times per week) to detect mass emergence of beetles in the spring. Focus insecticide applications on periods of heavy beetle activity. Evening sprays will reduce bee kill.

**Recommended Products**

Apply throughout the season when beetles exceed threshold.

- **Actara®** (25WDG) at 3-5.5 oz. per acre. Do not exceed 11 oz. per acre per season. See pollinator precautions. 0-day PHI.

- **Admire PRO®** (4.6F) at 7-10.5 fl. oz. per acre. Apply pre-plant in a band 2 inches or less, as an in-furrow spray at planting, as a post-plant drench, as a sidedress application, or through trickle irrigation water. Do not exceed 10.5 fl. oz. per acre per season. See pollinator precautions. 21-day PHI.

- **Ambush 2EC®** at 6.4-12.8 fl. 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 6.4 lbs. per acre. 0-day PHI. 

- **Asana XL®** (1.6) at 5.8-9.6 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. 3-day PHI. RUP.

- **Assail 30SG®** at 2.5-5.3 oz. per acre. Do not exceed 5 applications per season. 0-day PHI.

- **Azera®** at the following rates:
  - *Squash bug nymphs*: 32 fl. oz. per acre.
  - *Adult squash bugs and cucumber beetles*: 48 fl. oz. per acre.

  Use higher rates (48 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. 0-day PHI.

- **Baythroid XL®** (1EC) at 2.4-2.8 fl. oz. per acre. *Cucumber beetles only*. Do not exceed 11.2 fl. oz. or 4 applications per acre per season. Allow 7 days between applications. 0-day PHI. RUP.

- **Belay 2.13SC®** at 3-4 fl. oz. per acre. Do not apply during bloom. *Not for squash vine borers*. 7-day PHI.

- **Brigade®** (2EC) at 2.6-6.4 fl. oz. per acre (do not exceed 19.2 fl. oz. per acre per season), or **Brigade®** (WSB) at 8-16 oz. per acre (do not exceed 48 oz. per acre per season). 3-day PHI. RUP.

- **Danitol 2.4EC®** at 10.67-16 fl. oz. per acre. *Cucumber beetles only*. Do not exceed 42.67 fl. oz. per acre per season. 7-day PHI. RUP.

- **Kryocide®** at 8-16 lbs. per acre. Do not exceed 64 lbs. per acre per season. 7-day PHI for summer squash. 14-day PHI for all others.

- **Mustang Maxx®** at 2.8-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. RUP.

- **Pounce 25WP®** at 6.4-12.8 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. Cantaloupe: do not exceed 3.2 lbs. per acre. All others: do not exceed 4.8 lbs. per acre. 0-day PHI. RUP.

- **Prokil Cryolite 50D®** at 15-30.5 lbs. per acre. Do not exceed 153 lbs. per acre per season. 7-day PHI for summer squash. 14-day PHI for all others.

- **Sevin XLR PLUS®** (4F) at 1 qt. per acre. *Not for squash vine borer*. 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. 3-day PHI.

- **Warrior II®** at 1.28-1.92 fl. oz. per acre. Do not exceed 11.5 fl. oz. per acre per season. 1-day PHI. RUP.

**Mites**

**Recommended Products**

- **Acramite 50WS®** at 0.75-1 lb. per acre. One application per season only. Do not apply less than 50 gals. of water per acre. 3-day PHI.

- **Agri-Mek 0.15 EC®** at 8-16 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. Allow at least 7 days between applications. Do not make more than 2 sequential applications. Do not apply less than 20 gallons of water per acre. 7-day PHI.

- **Oberon 2SC®** at 7.0-8.5 fl. oz. per acre. Do not exceed 25.5 fl. oz. per acre per season. 7-day PHI.
**Portal®** (0.4EC) at 2 pts. per acre. *Melons and cucumber only*. Do not exceed 2 applications per season. 3-day PHI for melons. 1-day PHI for cucumber.

**Zeal®** (72WSP) at 2-3 oz. per acre. Do not exceed 1 application per season. 7-day PHI.

### Thrips

**Recommended Products**

**Admire PRO®** (4.6F) at 7-10.5 fl. oz. per acre. Apply preplant in a band 2 inches or less, as an in-furrow spray at planting, as a post-plant drench, as a sidedress application, or through trickle irrigation water. Do not exceed 10.5 fl. oz. per acre per season. See pollinator precautions. 21-day PHI.

**Entrust®** (2SC) at 6-8 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. 1-day PHI for cucumber. 3-day PHI for all others.

**Exirel®** (0.83E) at 13.5-20.5 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per season. See pollinator precautions. 1-day PHI.

**Platinum®** at 5-11 fl. oz. per acre. Do not exceed 11 fl. oz. per acre per season. 30-day PHI.

**Radiant SC®** at 6-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI for cucumber. 3-day PHI for all others.

### Whiteflies

**Recommended Products**

**Actara®** (25WDG) at 3-5.5 oz. per acre. Do not exceed 11 oz. per acre per season. See pollinator precautions. 0-day PHI.

**Admire PRO®** (4.6F) at 7-10.5 fl. oz. per acre. Apply preplant in a band 2 inches or less, as an in-furrow spray at planting, as a post-plant drench, as a sidedress application, or through trickle irrigation water. Do not exceed 10.5 fl. oz. per acre per season. See pollinator precautions. 21-day PHI.

**Assail 30SG®** at 2.5-5.3 oz. per acre. Do not exceed 5 applications per season. 0-day PHI.

**Beleaf 50SG®** at 2-8 oz. per acre. 0-day PHI.

**Brigade®** (2EC) at 5.2-6.4 fl. oz. per acre (do not exceed 19.2 fl. oz. per acre per season), or **Brigade®** (WSB) at 12.8-16.0 oz. per acre (do not exceed 48 oz. per acre per season). 3-day PHI. *RUP*.

**Exirel®** (0.83E) at 13.5-20.5 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per season. See pollinator precautions. 1-day PHI.

**Fulfill®** (50WDG) at 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. 0-day PHI.

**M-Pede®** at 1-2% by volume. Must contact whiteflies to be effective. 0-day PHI.

**Neemix®** according to label directions. 0-day PHI.

**Oberon 2SC®** at 7-8.5 fl. oz. per acre. Do not exceed 25.5 fl. oz. per acre per season. 7-day PHI.

**Platinum®** at 5-11 fl. oz. per acre. Do not exceed 11 fl. oz. per acre per season. 30-day PHI.

**Sivanto®** (200SL) at the following rates:

- **Soil application**: 21-28 fl. oz. per acre. 21-day PHI.
- **Foliar application**: 7-12 fl. oz. per acre. 1-day PHI.

**Venom®** at 1-4 oz. per acre. Do not exceed 6 oz. per acre per season. See pollinator precautions. 1-day PHI.

**Verimark 1.67SC®** at 10-13. 5 fl. oz. per acre via drip irrigation or soil injection. 1-day PHI.

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*This is a reduced-risk pesticide. See page 37 for details.

*May be acceptable for use in certified organic production. Check with your certifier before use.
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.

Ethephon 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 P₂O₅, and 0 to 300 pounds K₂O 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. K₂O 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 K₂O 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, O, and K₂O 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. Photos of the problems described below are provided on pages 227-230.

**Sunscauld:** 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.

### Varieties Table — Eggplant

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Season</th>
<th>Comments</th>
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</thead>
<tbody>
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<td>Good, but low yielding because of small fruit size</td>
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<tr>
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<tr>
<td>Epic</td>
<td>early</td>
<td>Oval</td>
</tr>
<tr>
<td>Ichiban</td>
<td>early</td>
<td>Long, slender</td>
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<tr>
<td>Little Fingers</td>
<td>early</td>
<td>Small, slender, borne in clusters</td>
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<td>Millionaire</td>
<td>early</td>
<td>Slender, black, purple calyx</td>
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<td>Kiko</td>
<td>early main</td>
<td>Holds color in fall</td>
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<tr>
<td>Ghostbuster</td>
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</tr>
<tr>
<td>Rosita</td>
<td>main</td>
<td>Lavender, long, cylindrical</td>
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</tbody>
</table>

### Disease Control for Eggplant

**Anthracnose**

Use disease-free seed and/or transplants. Practice a 3-4 year crop rotation.

**Recommended Products**

- **Aprovia Top** at 10.5-13.5 fl. oz. per acre. Use of a spreader-sticker is recommended. 0-day PHI.
- **Cabrio EG** at 8-12 oz. per acre. 0-day PHI.
- **Bravo**, **Echo**, and **Equis** are labeled for use at various rates. 3-day PHI.
- **Fontelis** at 24 fl oz per acre. Suppression only. See label for greenhouse uses. 0-day PHI.
- **Priaxor** at 4-8 fl. oz. per acre. 0-day PHI.
- **Quadris Flowable** at 6.0-15.5 fl. oz. per acre. 0-day PHI.
- **Quadris Top** at 8-14 fl. oz. per acre. 0-day PHI.
**Blossom End Rot**
Avoid drastic moisture fluctuations. Mulching plants may help. Avoid excessive nitrogen or potassium fertilization, rapid plant growth, and root pruning during cultivation. Maintain soil pH and calcium levels in desired range. Choose less susceptible varieties.

Blossom end rot is caused by a calcium deficiency in the fruit, although calcium levels in the soil may be sufficient. Wide fluctuations in soil water levels can trigger the disorder.

**Phytophthora Crown Rot**
Follow a 4-year rotation with crops outside the tomato/pepper/eggplant and cucurbit families. Choose fields with well-drained soil and avoid low spots. Use raised beds to promote drainage. Do not use irrigation water from a pond that collects runoff from fields infested with Phytophthora. Fungicides are not fully effective against this disease.

**Recommended Products**
- **Omega 500F®** at 1-1.5 pts. per acre. First application may be made as a drench at transplanting, followed by foliar applications. 30-day PHI.
- **Presidio 4SC®** at 3-4 fl. oz. per acre. Must be tank-mixed with a product of a different mode of action. 2-day PHI.
- **Ranman®** at 2.75 fl. oz. per acre. Alternate applications of Ranman® with fungicides that have a different mode of action. 0-day PHI.
- **Revus 2.09SC®** at 8 fl. oz. per acre. 1-day PHI.
- **Ridomil Gold SL®** treat soil at 1 pt. per acre broadcast (use less for band applications) before transplanting. Subsequent directed sprays may be needed. Phytophthora resistance to Ridomil® has been observed in some locations. 7-day PHI.

**Rhizoctonia Seedling Rot**
Seedlings may develop this disease under rainy conditions, especially in the spring and early summer. Plant crop on well-drained soil.

**Recommended Products**
- **Aframe®** 0.4-0.8 fl. oz. per 1,000 ft. of row. 0-day PHI.

**Southern Blight**
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.

**Verticillium Wilt**
Avoid fields with a history of Verticillium wilt. Rotate with small grains where possible.

Use of long rotations out of pepper/tomato/eggplant crops will prevent rapid increase of pathogen populations. Consider resistant (such as Irene) or partially resistant varieties.

**Recommended Products**
- **Vapam HL®** at 37.5-75 gals. per acre under plastic mulch. Allow at least 21 days between application of fumigant and transplanting. Observe the 48-hour REI. See label for important application instructions.
- **Actinovate AG®** at 3-12 oz. per acre. Use with a spreader-sticker. 0-day PHI.
- **Cabrio EG®** at 12-16 oz. per acre. *Suppression only. Not for greenhouse or high tunnel use.* 0-day PHI.
- **Contans WG®** at 1-4 lbs. per acre. Contans® is applied with conventional spray equipment directly to the soil surface at planting. See label for additional treatment information.
- **Priaxor®** at 4-8 fl. oz. per acre. *Suppression only. Not for greenhouse use.* 0-day PHI.

**Weed Control for Eggplant**
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.

For specific weeds controlled by each herbicide, check Table 25 on page 66.

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 Applications**

**Broadleaves and Grasses**

**Recommended Products**
- **Gramoxone Inteon 2L®** at 2-4 pts. per acre. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray
  - This is a reduced-risk pesticide. See page 37 for details.
  - This is a biopesticide. See page 37 for details.
  - May be acceptable for use in certified organic production. Check with your certifier before use.
solution. Broadcast before transplanting, or use lowest rate as a directed spray between rows after crop establishment. *RUP.*

**Glyphosate** products at 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 transplanting, or apply between crop rows with hooded or shielded sprayers or wiper applicators. Wait at least 3 days before transplanting. Remove herbicide residue from plastic mulch prior to transplanting. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

**Broadcast or Directed/Shielded Applications Broadleaves**

**Recommended Products**

*Aim EC*® at 0.5-2 fl. oz. per acre. 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.

**Preemergence Broadleaves and Grasses**

**Recommended Products**

*Devrinol 50DF-XT*® at 2-4 lbs. per acre. Apply before transplanting or within 48 hrs after transplanting. Do not exceed 1 application and 1.3 pts. per acre per year. *Growers in Michigan should be in possession of the 24(c) label.* 60-day PHI.

*Dual Magnum 7.62E*® at 0.5-1.33 pts. per acre. Apply before transplanting or within 48 hrs after transplanting. Do not exceed 1 application and 1.3 pts. per acre per year. *Growers in Michigan should be in possession of the 24(c) label.* 60-day PHI.

*Prowl H2O*® at 1-3 pts. per acre. Apply to soil before transplanting. Do not apply over the top of transplants. Needs water for activation. 70-day PHI.

**Trifluralin** products at 0.5-1 lb. a.i. per acre. Apply 4EC formulations at 1-2 pts. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate before transplanting, or apply directed spray between rows after transplanting and incorporate. Not effective on muck or high organic matter soils. May cause early stunting if growing conditions are unfavorable, especially on eggplant. To minimize injury, dip transplant roots in carbon slurry (2 lbs. per gal.) prior to planting, or include 2 oz. of carbon per gallon of transplant water.

**Preemergence Broadleaves**

**Recommended Products**

*Sandea*® at 0.5-1 oz. per acre. Apply between rows of crop, avoiding contact with crop. Avoid contact with surface of plastic mulch if present. Also controls nutsedge. Use lower rates on coarse soils with low organic matter. Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Not recommended for use under cool temperatures due to potential for crop injury. Do not exceed 2 applications and 2 oz. per acre per crop-cycle per year. 30-day PHI.

**Preemergence Grasses**

**Recommended Products**

*Dacthal W-75*® at 6-14 lbs. per acre, or *Dacthal Flowable*® at 6-14 pts. per acre. Apply 4-6 weeks after transplanting when growing conditions favor good plant growth. May be applied over the top of transplants.

**Postemergence Broadleaves and Grasses**

**Recommended Products**

*Gramoxone Inteon 2L*®. See details above for Burndown or Directed/Shielded Applications.

*Glyphosate* products. See details above for Burndown or Directed/Shielded Applications.

**Insect Control for Eggplant**

For combined insect control options in fruiting vegetables, see page 141.
### Fruiting Vegetables — Pepper

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Season</th>
<th>Fruit Shape</th>
<th>Color</th>
<th>DisTol/Res</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alliance</td>
<td>mid-early</td>
<td>blocky, 3-4 lobes</td>
<td>G&gt;R</td>
<td>BLS-1,2,3,4,5, CMV, PHY, PMV, PVY</td>
<td>Large peppers</td>
</tr>
<tr>
<td>Archimedes</td>
<td>main</td>
<td>blocky, 3-4 lobes</td>
<td>G&gt;R</td>
<td>BLS-1,2,3,7,8, PHY</td>
<td></td>
</tr>
<tr>
<td>Aristotle X3R</td>
<td>main</td>
<td>blocky</td>
<td>G&gt;R</td>
<td>BLS-1,2,3</td>
<td>Very consistent</td>
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<tr>
<td>Crusader</td>
<td>main</td>
<td>blocky</td>
<td>G&gt;R</td>
<td>BLS-1,2,3, TMV, PVY, PMV, Stip</td>
<td>Dark green</td>
</tr>
<tr>
<td>Declaration</td>
<td>early-main</td>
<td>blocky, 3-4 lobes</td>
<td>G&gt;R</td>
<td>BLS-1,2,3,5, CMV,PHY</td>
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<tr>
<td>Karisma</td>
<td>main</td>
<td>blocky, 3-4 lobes</td>
<td>G&gt;R</td>
<td>BLS-1,2,3, CMV,PMV,TMV,</td>
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<td>Lafayette</td>
<td>main</td>
<td>blocky</td>
<td>G&gt;Y</td>
<td>BLS-1,2,3, PVY</td>
<td>Not for sandy soils</td>
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<tr>
<td>Paladin</td>
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<td>long blocky</td>
<td>G&gt;R</td>
<td>PHY</td>
<td></td>
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<tr>
<td>PXX09941819</td>
<td>main</td>
<td>blocky, 3-4 lobes</td>
<td>G-R</td>
<td>BLS-1,2,3,4,5,</td>
<td>Large, blocky fruit</td>
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<tr>
<td>Revolution</td>
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<td>blocky</td>
<td>G&gt;R</td>
<td>BLS-1,2,3,5, CMV, PHY</td>
<td></td>
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<tr>
<td>Vanguard</td>
<td>main</td>
<td>blocky 4 lobe</td>
<td>G&gt;R</td>
<td>CMV,PHY, BLS-1,2,3,4,5</td>
<td>Large peppers, not recommended for Iowa</td>
</tr>
</tbody>
</table>

1. Immature to ripe fruit color: G=green, R=red, Y=yellow
2. Disease resistance or tolerance as reported by seed company. BLS-1,2,3=bacterial spot strains 1,2, and 3; CMV=cucumber mosaic virus; PHY=Phytophthora; PMV=pepper mottle virus; PVY=potato virus Y; TMV=tobacco mosaic virus.

<table>
<thead>
<tr>
<th>Colored Bells for trial</th>
<th>Gold Finch (yellow), Orange Grande, Oriole (orange), Sweet Chocolate, Blackbird (brown to black), Blue Jay (lilac), Islander (lavender), Tequila (green to purple to red), Blushing Beauty (ivory to red)</th>
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</thead>
<tbody>
<tr>
<td>Banana peppers/cubanelles</td>
<td>Sweet Banana (turns red at maturity), Key Largo (cubanelle, orange-red at maturity)</td>
</tr>
<tr>
<td>Sweet peppers</td>
<td>Aruba, Corno Verde, Giant Marconi</td>
</tr>
</tbody>
</table>

### Disease Control for Pepper

**Anthracnose**

Use disease-free seed and/or transplants. Practice a 3-4 year crop rotation.

**Recommended Products**

- **Aprovia Top** at 10.5-13.5 fl. oz. per acre. Use of a spreader-sticker is recommended. 0-day PHI.
- **Cabrio EG** at 8-12 oz. per acre. 0-day PHI.
- **Bravo**, **Echo**, and **Equus** are labeled for use at various rates. Not all chlorothalonil formulations are labeled for pepper. 3-day PHI.
- **Fontelis** at 24 fl. oz. per acre. *Suppression only*. See label for greenhouse uses. 0-day PHI.
- **Manzate Pro-Stick** at 1.6-2.1 lbs. per acre. 7-day PHI.
- **Priaxor** at 4-8 fl. oz. per acre. 0-day PHI.

**Quadris Flowable** at 6.0-15.5 fl. oz. per acre. 0-day PHI.

- **Quadris Top** at 8-14 fl. oz. per acre. 0-day PHI.
- **Tanos** at 8 oz. per acre. 3-day PHI.

**Bacterial Spot**

Resistant varieties are available for bacterial spot. Several races of bacterial spot can affect pepper.

Use disease-free seed and/or transplants. Consider seed treatment with hot water, HCL, or dilute Clorox. For more information, see Seed Treatments (page 26) or *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens* (Ohio State University Extension Fact Sheet HYG-3085-05), available from Ohioline, ohioline.osu.edu.

**Copper Resistance**: Strains of the bacterium that cause bacterial spot on tomato and pepper that are resistant to copper products are common in the Midwest. Using Actigard®, Agri-mycin 17®, Tanos®, and Serenade Max® as labeled may help manage copper-resistant strains.
Recommended Products

**Actigard** at 0.3-0.75 oz. per acre. Use low rate early in season and increase with time. See label. *Chili pepper only*. Use up to 8 weekly applications. May be effective when used with other labeled pesticides. 14-day PHI.

**Agri-mycin 17** at 200 ppm. Make one or two applications to seedlings, alternated with a fixed copper compound (see below) beginning at the two-leaf stage. Not labeled for use after transplanting.

Several formulations of copper products (e.g., Kocide®, Champ®, Cuprofix®) are labeled for greenhouse use at 1 tablespoon (TBSP) per 1,000 square feet rates. Repeat according to label directions. Carefully note re-entry and personal protection warnings.

**Copper** sprays in the field reduce the rate of bacterial spread. Avoid consecutive seasons with pepper or tomato in the same field. Avoid working in fields when plants are wet. Strains of copper-resistant bacteria causing bacterial spot have been found in the Midwest.

**Serenade Opti** at 14-20 oz. per acre. May help bacterial spot management when copper-resistant strains of the bacterium are present.

**Tanos 50DF** at 8 oz. per acre. Tanos® may help suppress bacterial diseases. Tank-mix as described on the label.

**Blossom End Rot**
Avoid drastic moisture fluctuations. Mulching plants may help. Avoid excessive nitrogen or potassium fertilization, rapid plant growth, and root pruning during cultivation. Maintain soil pH and calcium levels in desired range. Choose less susceptible varieties.

Blossom end rot is caused by a calcium deficiency in the fruit, although calcium levels in the soil may be sufficient. Wide fluctuations in soil water levels can trigger the disorder.

**Bacterial Canker**
Bacterial canker can occur in pepper but is relatively rare. However, infected peppers can serve as a source of inoculum for bacterial canker of tomato. Use disease-free seed and transplants (see comments for bacterial spot management). Transplant facility treatments listed under bacterial spot will help reduce the severity of bacterial canker. However, copper applications in the field are generally ineffective for controlling bacterial canker.

Fields with a history of bacterial canker should be planted to crops other than tomato, potato, pepper, or eggplant for at least three years. Sanitize machinery, seedlings, and plant production materials (transplant trays, greenhouse benches, and wooden stakes) with a disinfectant such as 10% chlorine bleach solution or another appropriate solution. Avoid working in wet fields.

**Recommended Products**

**Tanos 50DF** at 8 oz. per acre. Tanos® may help suppress bacterial diseases. Tank-mix with copper and mancozeb products.

**Phytophthora Blight**
Avoid areas of fields where waterlogged root zones persist throughout the season. Pepper is very susceptible to this disease. Use well-drained fields. Planting on raised beds will increase soil drainage. Rotate infested fields with non-host crops for several years.

Pepper varieties with moderate to good resistance to the crown and root rot phase of Phytophthora blight include: *Bell*: Paladin, Aristotle, Archimedes, Revolution, Declaration, Intruder, and Vanguard; *Jalapeño*: Hechicero; *Ancho*: Sequoia. These varieties are susceptible to the foliar and fruit rot phases of Phytophthora blight. Where this disease is a recurring problem, use a fungicide program combined with Phytophthora-resistant pepper varieties.

*Timing is Critical*: Fungicides applied for Phytophthora blight are most effective if applied when disease threatens, but before symptoms become severe.

**Recommended Products**

**Agri-Fos 50WP**. See label for rate. 0-day PHI.

**Omega 500F** at 1-1.5 pts. per acre. First application may be made as a drench at transplanting, followed by foliar applications. 30-day PHI.

**Orondis Opti**. Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack. 0-day PHI.

**Orondis Ridomil Gold SL**. Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack to soil only. 7-day PHI.

**Orondis Ultra**. Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack. 0-day PHI.

**Phostrol** at 1-2 qts. per acre. 0-day PHI.

**Presidio 4SC** at 3-4 fl. oz. per acre. 2-day PHI.

**Ranman** at 2.75 fl. oz. per acre. 0-day PHI.

**Revsus** at 8 fl. oz. per acre. 1-day PHI.

**Ridomil Gold SL** soil treatment at 1 pt. per acre broadcast (use less for band applications) before transplanting. Subsequent directed sprays may be needed. *Phytophthora crown rot only*. Fungicides will not be effective if pepper is planted in poorly drained fields with a history of the disease. 7-day PHI.

**Tanos 50WDG** at 8-10 oz. per acre. 3-day PHI.

**Zampro** at 14 fl. oz. per acre. Do not exceed 3 applications per season. First application may be made at transplanting as a seedling drench. 4-day PHI.
**Powdery Mildew**

**Recommended Products**

- **Aprovia Top®** at 10.5-13.5 fl. oz. per acre. Use of a spreader-sticker is recommended. 0-day PHI.
- **Cabrio®** at 8-16 oz. per acre. 0-day PHI.
- **Quadris 2.08EC®** at 6-15.5 fl. oz. per acre. Apply at 7-14 day intervals. 0-day PHI.
- **Quadris Top®** at 8-14 fl. oz. per acre. Make no more than 2 consecutive applications before switching to a product with a different mode of action. 0-day PHI.
- **Quintec®** at 4-6 fl. oz. per acre. 3-day PHI.
- **Rally 40WSP®** at 2.5-4.0 oz. 0-day PHI.

**Southern Blight**

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.

**Recommended Products**

- **Terraclor®**. See label for rate. May be applied as a transplant solution or in-furrow.

**Virus Diseases**

Grow resistant varieties. Plant disease-free transplants. Eliminate broadleaf weeds within 150 feet of field before crops are established.

Some broadleaf weeds may be reservoirs for pepper viruses. Aphids may spread virus diseases from weeds to peppers and from diseased peppers to healthy peppers. Oil sprays timed with aphid flight periods may prevent virus transmission by aphids but have short-term residual effectiveness. Light-colored and reflective mulches may deter aphids from landing on plants and transmitting the virus.

**White Mold**

Avoid fields with history of the problem. Pathogen has large host range. Avoid tomato after tomato rotations.

**Recommended Products**

- **Actinovate AG®** at 3-12 oz. per acre. Use with a spreader-sticker. 0-day PHI.
- **Cabrio EG®** at 12-16 oz. per acre. *Suppression only. Not for greenhouse or high tunnel use.* 0-day PHI.
- **Contans WG®** at 1-4 lbs. per acre. Contans® is applied with conventional spray equipment directly to the soil surface at planting. See label for additional treatment information.
- **Priaxor®** at 4-8 fl. oz. per acre. *Suppression only. Not for greenhouse use.* 0-day PHI.

**Weed Control for Pepper**

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. Processing peppers are commonly grown in double rows on flat or raised beds. Weeds are controlled with a combination of herbicides and cultivation.

For specific weeds controlled by each herbicide, check Table 25 on page 66.

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 Applications Broadleaves and Grasses**

**Recommended Products**

- **Gramoxone Inteon 2L®** at 2-4 pts. per acre. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Broadcast before transplanting, or use lowest rate as a directed spray between rows after crop establishment. 30-day PHI for tomato. *RUP.*
- **Glyphosate** products at 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 transplanting, or apply between crop rows with hooded or shielded sprayers or wiper applicators. Wait at least 3 days before transplanting. Remove herbicide residue from plastic mulch prior to transplanting. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

This is a reduced-risk pesticide. See page 37 for details.

This is a biopesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.
Fruiting Vegetables — Pepper - Weed Control

**Burndown or Directed/Shielded**

**Applications Broadleaves**

**Aim EC** at 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.

**Recommended Products**

*Preemergence Broadleaves and Grasses*

**Recommended Products**

**Command 3ME** at 0.67-2.67 pts. per acre. *Not for banana pepper except in Ohio*. Use lower rate on coarse soils, and higher rate on fine soils. Apply before transplanting. May cause temporary bleaching of crop leaves.

**Devrinol 50DF** at 2-4 lbs. per acre. Use lower rate on coarse soil. Apply and incorporate before seeding or transplanting. 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.

**Dual Magnum** at 0.5-1 pt. per acre. *Indiana and Ohio only*. 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. 60-day PHI.

**Prowl H2O** at 1-3 pts. per acre. *Not for use under plastic mulch*. Apply and incorporate before planting, apply before planting without incorporation, or apply to established transplants as a directed spray. Avoid any contact with leaves or stems of crop. 70-day PHI.

**Reflex 2L** at 1 pt. per acre. Apply before transplanting pepper. For use under plastic, apply after bed formation and before laying plastic. Use only once in twice per year on the same soil. See rotational crop restrictions. *Growers in Michigan should be in possession of the 24(c) label*. 60-day PHI.

**Trifluralin** products at 0.5-1 lb. a.i. per acre. Apply 4EC formulations at 1-2 pts. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate before transplanting, or apply directed spray between rows after transplanting and incorporate. Not effective on muck or high organic matter soils. 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 gallon of transplant water.

**Preemergence Broadleaves**

**Recommended Products**

**Sandea** at 0.5-1 oz. per acre. Apply between rows of crop, avoiding contact with crop. Avoid contact with surface of plastic mulch if present. Use lower rates on coarse soils with low organic matter. Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Also controls nutsedge. Not recommended for use under cool temperatures due to potential for crop injury. Do not exceed 2 applications and 2 oz. per acre per crop-cycle per year. 30-day PHI.

**Spartan Charge** at 4.5-7.6 fl. oz. per acre. *For use on peppers grown on plastic mulch in Ohio only*. Controls apple of Peru, ALS-resistant lambsquarters, and yellow nutsedge. Apply with directed, shielded sprayer. Before transplanting apply up to shoulders of plastic mulch covered bed, or after transplanting apply to row middles. Do not exceed 7.6 fl. oz. per acre per 12-month period.

**Postemergence Broadleaves**

**Recommended Products**

**Aim EC** at 1 pt. per acre. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting.

**Postemergence Grasses**

**Recommended Products**

**Prefar 4E** at 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting.

**Postemergence Broadleaves**

**Recommended Products**

**Gramoxone Inteon 2L**. See details above for Burndown or Directed/Shielded Applications.

**Glyphosate** products. See details above for Burndown or Directed/Shielded Applications.

**Postemergence Grasses**

**Recommended Products**

**Spartan Charge®** at 4.5-7.6 fl. oz. per acre. *For use on peppers grown on plastic mulch in Ohio only*. Controls apple of Peru, ALS-resistant lambsquarters, and yellow nutsedge. Apply with directed, shielded sprayer. Before transplanting apply up to shoulders of plastic mulch covered bed, or after transplanting apply to row middles. Do not exceed 7.6 fl. oz. per acre per 12-month period.

**Preemergence Grasses**

**Recommended Products**

**Prefar 4E** at 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting.

**Postemergence Broadleaves and Grasses**

**Recommended Products**

**Prefar 4E** at 5-6 qts. per acre. Use low rate on soils with less than 1% organic matter. Apply and incorporate before planting.

**Postemergence Broadleaves**

**Recommended Products**

**Aim®. See details above for Burndown or Directed/Shielded Applications.**

**Sandea®. See details above for Preemergence. Also controls nutsedge.**

**Postemergence Grasses**

**Recommended Products**

**Clethodim products at the following rates:**

**Select Max® at 9-32 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.**

**2EC formulations of clethodim products at 6-16 fl. oz. per acre. Use 2EC formulations 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. 20-day PHI.**

Spray on actively growing grass. Wait at least 14 days between applications.

**Poast 1.5E® at 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 4.5 pts. per acre per season. 20-day PHI.**
Insect Control for Pepper

For combined insect control options in fruiting vegetables, see page 141.

Fruiting Vegetables — Tomato

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Season</th>
<th>Crack Resistance</th>
<th>Firmness</th>
<th>Vine Type¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunshine</td>
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<td>firm</td>
<td>D</td>
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<td>Jet Star</td>
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<td>firm</td>
<td>D</td>
</tr>
<tr>
<td>Florida 47</td>
<td>main</td>
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<td>firm</td>
<td>D</td>
</tr>
<tr>
<td>Mountain Fresh</td>
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<td>firm</td>
<td>D</td>
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<tr>
<td>Sun Leaper</td>
<td>main-late</td>
<td>firm</td>
<td>D</td>
<td></td>
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</tbody>
</table>

For trial: Primo Red (early), Linda, Tribute, HM8849, Mt. Glory, BHN 876

Yellow: Carolina Gold, Lemon Boy. For trial: BHN 876.

Cherry types: Mountain Belle

Grape types: Santa (indeterminate), Sweet Olive (determinate), Jolly Elf (determinate, for trial), Golden Sweet (yellow)

Roma types: BHN 411, Plum Dandy, LaRossa

¹Vine Type: I=indeterminate (long vine); D=determinate (short vine).

Disease Control for Tomato

**Anthracnose**

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.

**Recommended Products**

**Aprovia Top** at 10.5-13.5 fl. oz. per acre. Use of a spreader-sticker is recommended. 0-day PHI.

**Cabrio EG** at 8-12 oz. per acre. See label to avoid practices that could result in crop injury. 0-day PHI.

**Bravo**, **Echo**, and **Equus** formulations are labeled for use at various rates. 0-day PHI.

**Dithane**, **Manzate**, and **Penncozeb** formulations are labeled at various rates. 5-day PHI.

**Fontelis** at 24 fl. oz. per acre. *Suppression only*. See label for greenhouse uses. 0-day PHI.

**Inspire Super** at 16-20 fl. oz. per acre. Do not apply to small fruit such as cherry tomato. 0-day PHI.

**Priaxor** at 4-8 fl. oz. per acre. 0-day PHI.

**Quadris Flowable** at 5-6.2 fl. oz. per acre. 0-day PHI.

**Quadris Opti** at 1.6 pts. per acre. 0-day PHI.

**Quadris Top** at 8 fl. oz. per acre. 0-day PHI.

**Revis Top 2.08SC** at 5.5-7 fl. oz. per acre. Do not use on small-fruited varieties. Use when late blight is also a concern. 1-day PHI.

**Tanos** at 8 oz. per acre. 3-day PHI.

**Bacterial Canker**

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/Speck (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 solution or another appropriate solution. Avoid working in wet fields.

Winter/off-season: Rotate crops at least 3 years and practice fall tillage. May be seedborne. Consider seed treatment with hot water, HCL, or dilute Clorox. For more information, see Seed Treatments (page 26) or *Hot Water and Chlorine Treatment of Vegetable Seeds to Eradicate Bacterial Plant Pathogens* (Ohio State University Extension Fact Sheet HYG-3085-05), available from Ohioline, ohioline.osu.edu.

Greenhouse: Inspect seedlings for disease and apply one or two fixed copper product applications. Tank-mix copper product with mancozeb (see bacterial spot/speck 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.

**Recommended Products**

*Tanos 50DF®* at 8 oz. per acre. *Tanos®* may help suppress bacterial diseases. Tank-mix with copper and mancozeb products.

**Bacterial Spot/Speck**

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 have been reported in the Midwest. *Actigard®*, *Agri-mycin 17®*, mancozeb products, *Tanos®, and Serenade Max®* 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.

Greenhouse: Scout and apply fixed copper if disease threatens.

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**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.

**Recommended Products**

*Actigard 50WG®* at 0.3-0.75 oz. per acre. Begin season with lower rate and increase as plant canopy increases. Do not exceed 6 oz. per season. 14-day PHI.

*Agri-mycin 17®* or *Harbour®* at 200 ppm. Apply one or two times to seedlings, alternated with a fixed copper compound (see below) beginning at the two-leaf stage. Not labeled for use after transplanting (greenhouse only).

Several formulations of copper products (Badge®, Champ®, Cueva®, Cuprofix®, Kentan®, Kocide®, Nordox®) are labeled for greenhouse use. Apply according to label directions.

Copper sprays in the field may reduce the rate of bacterial spread. Copper-resistant strains of the bacterial spot pathogen are common in the Midwest. Avoid consecutive seasons with pepper or tomato in the same field. Avoid working in fields when plants are wet. Mancozeb products (e.g., Dithane®, Manzate®, and Penncozeb®) when applied with copper products, allow more copper to become available, so may help manage copper-resistant bacterial spot strains.

*Serenade Opti®* at 14-20 oz. per acre. Alternate with copper products. May help bacterial spot management when copper-resistant strains of the bacterium are present.

*Tanos 50DF®* at 8 oz. per acre. *Tanos®* may help suppress bacterial diseases. Tank-mix with copper and mancozeb products.

**Blossom End Rot**

Avoid drastic moisture fluctuations. Mulching plants may help. Avoid excessive nitrogen or potassium fertilization, rapid plant growth, and root pruning during cultivation. Maintain soil pH and calcium levels in desired range. Choose less susceptible varieties.

Blossom end rot is caused by a calcium deficiency in the fruit, although calcium levels in the soil may be sufficient. Wide fluctuations in soil water levels can trigger the disorder.

**Botrytis Gray Mold**

This disease is observed primarily in greenhouses and high tunnels where it causes dieback of tomato leaves and lesions on fruit.
Winter/Off-season: Rotate crops at least 2-3 years and practice fall tillage. Keep up plant’s calcium levels.

Greenhouse/High tunnel: Keep temperatures higher than 70°F, and maintain relative humidity less than 90%. Keep plants well pruned to improve air circulation.

Planting: Begin protective fungicide applications.

Harvest: Inspect fruit for symptoms.

**Recommended Products**

*Botran 75W* at 1 lb. per 100 gals. of water. Labeled for the stem phase of gray mold. Apply to stems up to a height of 24 inches. Young plants may be injured. Available for greenhouse use.

Several chlorothalonil formulations (e.g., *Bravo*, *Echo*, *Equus*) are available at various rates. *Field use only*. 0-day PHI.

*Cabrio* at 12-16 oz. per acre. *Suppression only*. 0-day PHI.

*Endura* at 9-12.5 oz. per acre. *Suppression only*. 0-day PHI.

*Fontelis* at 16-24 fl. oz. per acre. See label for greenhouse uses. 0-day PHI.

*Priaxor* at 4-8 fl. oz. per acre. *Suppression only*. 0-day PHI.

*Scala* at 7 fl. oz. per acre. May be used in greenhouses (see label for cautions). 1-day PHI.

*Switch 62.5WB* at 11-14 oz. per acre. 0-day PHI.

**Buckeye Rot and Phytophthora Blight**

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.

**Recommended Products**

*Gavel 75DF* at 1.5-2 lbs. per acre. 5-day PHI.

*Orondis Opti*. Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack. 0-day PHI.

*Orondis Ridomil Gold SL*. Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack to soil only. 7-day PHI.

*Orondis Ultra*. Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack. 0-day PHI.

*Presidio 4SC* at 3-4 fl. oz. per acre. Must be tank-mixed with a product with a different mode of action. 2-day PHI.

*Quadris 2.08EC* at 5.0-6.0 fl. oz. per acre. 0-day PHI.

*Quadris Opti* at 1.6 pts. per acre. 0-day PHI.

*Rannman 400SC* at 2.75 fl. oz. per acre. Apply product to base of plant or in transplant water at transplanting. Do not exceed 16.5 fl. oz. per acre per season. 0-day PHI.

*Ridomil Gold SL* at 1.0 pts. per acre. Apply at least 4 weeks before harvest.

*Tanos* at 8 oz. per acre. *Suppression only*. Must be tank-mixed. 3-day PHI.

*Zampro* at 14 fl. oz. per acre. No more than 3 applications per season. First application may be made at transplanting as a seedling drench. 4-day PHI.

**Early Blight and Septoria Leaf Blight**

Both of these diseases 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 Table 29 (page 76) for more information.

Winter/Off-season: Use crop rotations of at least 2-3 years for Septoria and 3-4 years for early blight.

Planting: Begin protective fungicide applications on a 7-14 day schedule.

**Recommended Products**

*Aprovia Top* at 10.5-13.5 fl. oz. per acre. Use of a spreader-sticker is recommended. 0-day PHI.

*Bravo*, *Echo*, and *Equus* are labeled at various rates. 0-day PHI.

*Cabrio EG* at 8-12 oz. per acre. 0-day PHI.

*Dithane*, *Mancozeb*, and *Penncozeb* are labeled at various rates. 5-day PHI.
Endura 70WG® at 2.5-3.5 oz. per acre. Early blight only. 0-day PHI.

Fontelis® at 16-24 fl. oz. per acre. See label for greenhouse uses. 0-day PHI.

Gavel 75DF® at 1.5-2 lbs. per acre. 5-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. Do not apply to small-fruited varieties such as cherry tomato. 0-day PHI.

OSO 5%EC® at 3.7-13 fl. oz. per acre. Early blight only. 0-day PHI.

Priaxor® at 4-8 fl. oz. per acre. 0-day PHI.

Quadris 2.08EC® at 5.0-6.2 fl. oz. per acre. 0-day PHI.

Quadris Opti® at 1.3-1.6 pts. per acre. 0-day PHI.

Quadris Top® at 8 fl. oz. per acre. 0-day PHI.

Reason® at 5.5-8.2 fl. oz. per acre. Label indicates suppression only for Septoria. 14-day PHI.

Revus Top 2.08SC® at 5.5-7 fl. oz. per acre. 1-day PHI.

Scala® at 7 fl. oz. per acre. Early blight only. Use only in a tank-mix with another fungicide effective against early blight. May be used in greenhouses (see label for cautions). 1-day PHI.

Switch 62.5WB® at 11-14 oz. per acre. Early blight only. Do not apply to small-fruited varieties in the greenhouse. 0-day PHI.

Tanos® at the following rates:
   Early blight: 6-8 oz. per acre.
   Septoria: 8 oz. per acre.
   3-day PHI.

Zing 4.9SC® at 36 fl. oz. per acre. 5-day PHI.

Ziram 76DF® at 3-4.0 lbs. per acre. Not for cherry tomato. Use with effective spreader-sticker. 7-day PHI.

**Fusarium Crown and Root Rot**

Use long crop rotations. Steam or fumigate soil in the greenhouse prior to transplanting.

**Fusarium Wilt**

Plant resistant varieties. Avoid fields with a history of root knot nematode.

**Late Blight**

The fungus that causes late blight does not overwinter in the Midwest. Thus, the fungus must be transported into the Midwest each time the disease occurs.

Winter/Off season: Destroy cull plies and disk under tomato fields at the end of each season.

Planting: Apply specialized fungicides when late blight threatens.

Harvest: Inspect fruit for symptoms of late blight.

**Recommended Products**

- **Agri-Fos 50WP®**: See label for rate. 0-day PHI
- Chlorothalonil and mancozeb products may be used. Higher rates may be required for late blight control. 0-day PHI for chlorothalonil. 5-day PHI for mancozeb. Best used in tank-mixes with other products listed here.
- Curzate 60DF® at 3.2-5 oz. per acre. Apply Curzate® plus a contact (protectant) fungicide. Use the 5 oz. rate if late blight is present. 3-day PHI.
- Gavel 75DF® at 1.5-2 lbs. per acre. 5-day PHI.
- Orondis Opti®, Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack. 3-day PHI.
- Orondis Ultra®, Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack. 1-day PHI.
- Previcur Flex® at 0.7-1.5 pts. per acre. See label for greenhouse instructions. 5-day PHI.
- Presidio® at 3-4 fl. oz. per acre. 2-day PHI.
- Priaxor® at 8 fl. oz. per acre. Suppression only. 0-day PHI.
- Ranman 400SC® at 2.1-2.75 fl. oz. per acre. 0-day PHI.
- Reason 500SC® at 5.5-8.2 fl. oz. per acre. 14-day PHI.
- Revus Top 2.08SC® at 5.5-7 fl. oz. per acre. 1-day PHI.
- Ridomil Gold Bravo SC® at 2.5 pt. per acre. Use only when late blight strains in the area are known to be sensitive to Ridomil®. Tank-mix with a penetrating surfactant. Do not use a sticker. 5-day PHI.
- Tanos 50WP® at 8 oz. per acre. Tank-mix with a contact fungicide with a different mode of action. 3-day PHI.
- Zampro® at 14 fl. oz. per acre. 4-day PHI.
- Zing 4.9SC® at 36 fl. oz. per acre. 5-day PHI.

**Leaf Mold**

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.

- This is a reduced-risk pesticide. See page 37 for details.
- This is a biopesticide. See page 37 for details.
- May be acceptable for use in certified organic production. Check with your certifier before use.
**Recommended Products**

Dithane®, Manzate®, and Penncozeb® are labeled at various rates. Label is silent on greenhouse use. 5-day PHI.

Gavel 75DF® at 1.5-2 lbs. per acre. Label is silent on greenhouse use. 5-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. Do not apply to small-fruited varieties such as cherry tomato. Label is silent on greenhouse use. 0-day PHI.

Quadris Top® at 8 fl. oz. per acre. Label is silent on greenhouse use. 0-day PHI.

Tanos® at 8 oz. per acre. Label is silent on greenhouse use. 3-day PHI.

**Powdery Mildew**

**Recommended Products**

Aprovia Top® at 10.5-13.5 fl. oz. per acre. Use of a spreader-sticker is recommended. 0-day PHI.

Cabrio® at 8-16 oz. per acre. 0-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. Do not apply to small-fruited varieties such as cherry tomato. 0-day PHI.

Priaxor® at 6-8 fl. oz. per acre. 0-day PHI.

Quadris 2.08EC® at 5.0-6.2 fl. oz. per acre. 0-day PHI.

Quadris Opti® at 1.6 pts. per acre. 0-day PHI.

Quadris Top® at 8-14 fl. oz. per acre. 0-day PHI.

Quintec® at 4-6 fl. oz. per acre. Must have supplelental label. 3-day PHI.

Rally 40WSP® at 2.5-4.0 oz. 0-day PHI.

Switch® at 11 oz. per acre. *Not for small-fruited varieties in the greenhouse.* 0-day PHI.

Vivando® at 15.4 fl. oz. per acre. Must have supplelental label. 0-day PHI.

**Rhizoctonia Seedling Rot**

Seedlings may develop this disease under rainy conditions, especially in the spring and early summer. Plant crop on well-drained soil.

**Recommended Products**

Aframe® at 0.4-0.8 fl. oz. per 1,000 ft. of row. 0-day PHI.

**Southern Blight**

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.

**Recommended Product**

Terraclor® See label for rate. May be applied as a transplant solution or in-furrow.

**Tobacco Mosaic Virus**

This disease is more of a problem in fresh market tomatoes than processing tomatoes due to extensive handling. The best control is to use a resistant cultivar. There is no chemical control. If only a few plants are showing symptoms, remove them carefully so as not to touch other plants. Control weeds around fields, because some weeds are known to harbor the virus.

**Tomato Spotted Wilt Virus/Tomato Chlorotic Spot Virus**

These viruses are carried by thrips and can cause major loss to tomatoes if they infect young plants. If southern-grown transplants are used, growers should be certain that they are from inspected, disease-free fields. Northern-grown transplants should be grown in isolation from ornamental plants. Controlling thrips may slow the spread of the virus in greenhouse and field.

**Verticillium Wilt**

Many tomato cultivars have host resistance to Verticillium wilt. Avoid fields with a history of Verticillium wilt. Rotate with small grains where possible. Use of long rotations out of solanaceous crops will prevent rapid increase of pathogen populations. Tomato varieties with resistance are available.

**Recommended Products**

Fumigate with Vapam® at 37.5-75 gals. per acre under plastic mulch. *Not for greenhouse use.* Allow at least 21 days between application of fumigant and transplanting. Observe the 48-hour REI. See label for important application instructions.

**White Mold (Timber Rot)**

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 large host range. Avoid tomato after tomato rotations.

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.

**Recommended Products**

Actinovate AG® at 3-12 oz. per acre. Use with a spreader-sticker. 0-day PHI.

Cabrio EG® at 12-16 oz. per acre. *Suppression only. Not for greenhouse or high tunnel use.* 0-day PHI.

Contans WG® at 1-4 lbs. per acre. Contans® is applied with conventional spray equipment directly to the soil surface at planting. See label for additional treatment information.

Priaxor® at 4-8 fl. oz. per acre. *Suppression only. Not for greenhouse use.* 0-day PHI.
# Product/Disease Ratings for All Fruiting Vegetables

<table>
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<tr>
<th>Product (REI/PHI)</th>
<th>Common Name</th>
<th>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.</th>
<th>Anthracnose (tomato)</th>
<th>Anthracnose (pepper)</th>
<th>Bacterial Canker</th>
<th>Bacterial Spot</th>
<th>Botox</th>
<th>Gray Mold</th>
<th>Early Blight</th>
<th>Septoria Leaf Blight</th>
<th>Late Blight (tomato)</th>
<th>Phytophthora Blight (pepper)</th>
<th>(leaf)</th>
<th>(bacterial)</th>
<th>Bushy Blight</th>
<th>Leaf Mold</th>
<th>White Mold</th>
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<td>Agri-Mycin 17®, Ag Streptomycin*</td>
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</table>

1. 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.
2. 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.
Weed Control for Tomato

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. Processing tomatoes are commonly grown in double rows on flat or raised beds. Weeds are controlled with a combination of herbicides and cultivation.

For specific weeds controlled by each herbicide, check Table 25 on page 66.

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 Applications Broadleaves and Grasses

Recommended Products

**Glyphosate** products at 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 transplanting, or apply between crop rows with hooded or shielded sprayers or wiper applicators. Remove herbicide residue from plastic mulch prior to transplanting. Do not use row-middle applications for tomatoes grown on sandy soils because crop injury may occur. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. 14-day PHI.

**Gramoxone Inteon 2L** at 2-4 pts. per acre. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Broadcast before transplanting, or use lowest rate as a directed spray between rows after crop establishment. 30-day PHI for tomato. RUP.

**Burndown or Directed/Shielded Applications Broadleaves**

**Recommended Products**

**Aim EC** at 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.

Preemergence Broadleaves and Grasses

**Recommended Products**

**Devrinol 50DF** at 2-4 lbs. per acre. Use lower rate on coarse soil. Apply and incorporate before seeding or transplanting. 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.

**Dual Magnum** at 1-2 pts. per acre. Use lower rate on coarse soils. Apply prior to transplanting, or as a directed spray after transplanting. Crop injury may occur under unfavorable growing conditions. Not recommended for fresh market tomatoes. 30- to 90-day PHI depending on rate.

**Matrix 25DF** at 1-2 oz. per acre. Use 0.5 pt. of NIS per 25 gals. of spray solution 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. 45-day PHI.

**Prowl H2O** at 1-3 pts. per acre. Not for use under plastic mulch. Apply and incorporate before planting, apply before planting without incorporation, or apply to established transplants as a directed spray. Avoid any contact with leaves or stems of crop. 70-day PHI.

**Trifluralin** products at 0.5-1 lb. a.i. per acre. Apply 4EC formulations at 1-2 pts. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate before transplanting, or apply directed spray between rows after transplanting and incorporate. Not effective on muck or high organic matter soils. 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.
**Fruiting Vegetables — Tomato - Weed Control**

**Preemergence Broadleaves**

**Recommended Products**

- **Sandea®** at 0.5-1 oz. per acre. Use lower rates on coarse soils with low organic matter. Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Apply to soil surface after final soil preparation or bed shaping and just before applying plastic mulch. Wait 7 days after application and laying mulch before transplanting. Or apply between rows of crop, avoiding contact with crop and surface of plastic mulch, if present. For tomatoes on bare ground only, apply over the top of well-established, actively growing plants no sooner than 14 days after transplanting and before first bloom. Also controls nutsedge. Not recommended for use under cool temperatures due to potential for crop injury. Do not exceed 2 applications and 2 oz. per acre per crop-cycle per year. 30-day PHI.

- **Sencor 4F®** at 0.5-1 pt. per acre, or **Sencor 75DF®** at 0.33-0.66 lb. per acre. Broadcast and incorporate before transplanting, or broadcast after transplants are established. Or, use Sencor 4F® at up to 2 pts. per acre, or Sencor 75DF® 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 Sencor 4F®, or 1.33 lbs. of Sencor 75DF® per acre per season. 7-day PHI.

- **Spartan 4F®** at 2.25 to 8 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. Maximum per acre per 12 months is 12 oz.

**Preemergence Grasses**

**Recommended Products**

- **Dacthal W-75®** at 6-14 lbs. per acre, or **Dacthal Flowable®** at 6-14 pts. per acre. Apply 4-6 weeks after transplanting when growing conditions favor good plant growth. May be applied over the top of transplants.

**Postemergence Broadleaves and Grasses**

**Glyphosate** products. See details above for Burndown or Directed/Shielded Applications.

- **Gramoxone Inteon 2L®**. See details above for Burndown or Directed/Shielded Applications.

- **Matrix 25DF®** See details above for Preemergence.

**Postemergence Broadleaves**

**Recommended Products**

- **Sandea®**. See details above for Preemergence. Also controls nutsedge.

- **Sencor®**. See details above for Preemergence.

**Postemergence Grasses**

**Recommended Products**

**Clethodim** products at the following rates:

- **Select Max®** at 9-32 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

- **2EC formulations of clethodim products** at 6-16 fl. oz. per acre. Use 2EC formulations 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. 20-day PHI.

Spray on actively growing grass. Wait at least 14 days between applications.

- **Poast 1.5E®** at 1-1.5 pts. per acre. Use 1 qt. COC per acre. Spray on actively growing grass. Use high rate on quackgrass. Do not exceed 4.5 pts. per acre per season. 20-day PHI.

**Insect Control for Tomato**

For combined insect control options in fruiting vegetables, see page 141.
### Herbicides for All Fruiting Vegetables

<table>
<thead>
<tr>
<th>Products (REI/PHI)</th>
<th>Common Name</th>
<th>Timing and Application Location Relative to Crop</th>
<th>Timing Relative to Weeds</th>
<th>Weed Groups Controlled</th>
<th>Crops</th>
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<tbody>
<tr>
<td>Aim EC* (12h/-)</td>
<td>carfentrazone</td>
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<td>Command 3ME* (12h/-)</td>
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<td>Sandea* (12h/30d)</td>
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1For effectiveness against specific weeds, see Table 25 on page 66, 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.

2X=permited for at least one crop.

3*=May be used for that crop if it is not on plastic mulch.

### Insect Control for all Fruiting Vegetables

#### Aphids

Conservate natural enemies.

Limiting the use of some insecticides will conserve predators and parasites that help control aphid populations.

**Recommended Products**

- **Actara**® (25 WDG) at 2-3 oz. per acre. 0-day PHI.

- **Admire PRO**® (4.6F) at the following rates:
  
  - **Soil-applied to pepper:** 7-14 fl. oz per acre. 21-day PHI.
  - **Soil-applied to all others:** 7-10.5 fl. oz. per acre. 7-day PHI.
  - **Foliar applications:** 1.3-2.2 fl. oz. per acre.

- **Assail**® (30SG) at 2-4 oz. per acre. 7-day PHI.

- **Belay**® (2.13SC) at 3-4 fl. oz. per acre. 7-day PHI for eggplant and tomato. 1-day PHI for pepper.

- **Beleaf**® (50SC) at 2-2.8 fl. oz. per acre. *Aphids only.* 0-day PHI.

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*This is a reduced-risk pesticide. See page 37 for details.*
Dimethoate 400® or Dimethoate 4E® at 0.5-1 pt. per acre. Pepper and tomato only. 7-day PHI for tomato. 2-day PHI for pepper.

Fulfill® (50WDG) at 2.75 oz. per acre. 0-day PHI.

Lannate LV® (2.4 WSL) at 1.5-3 pts. per acre. 1-day PHI for tomato. 3-day PHI for pepper. 5-day PHI for eggplant. RUP.

Malathion 5EC® at 1.5 pt per acre. 1-day PHI.

Movento® at 4-5 fl. oz. per acre. 1-day PHI.

M-Pede® at 1-2% by volume. Must contact aphids to be effective. 0-day PHI.

Orthene® (97S) at 0.5-1 lb. per acre. Pepper only. 7-day PHI.

Platinum® (2SC) at 5-11 fl. oz. per acre. 30-day PHI.

Sivanto® (200SL) at the following rates:

- **Foliar applications**: 7-12 fl. oz. per acre. 1-day PHI.
- **Soil applications**: 21-28 fl. oz. per acre. 45-day PHI.

Vydate L® (2WSL) at 2-4 pts. per acre. 7-day PHI for pepper. 1-day PHI for eggplant. 3-day PHI for tomato. RUP.

**Colorado Potato Beetles**

(tomato and eggplant only)

Practice crop rotation. Plant as far away as possible from last season’s potato, tomato, or eggplant fields to reduce damage.

Regular (weekly) scouting will allow you to determine the need for insecticides and to improve application timing.

**Recommended Products**

Admire PRO® (4.6F) at the following rates:

- **Soil applications**: 7-10.5 fl. oz. per acre. 21-day PHI.
- **Foliar applications**: 1.3-2.2 fl. oz. per acre. 7-day PHI.

Agri-Mek® (0.15EC) at 8-16 fl. oz. per acre. 7-day PHI.

Ambush 2EC® at 3.2-12.8 fl. oz. per acre. 3-day PHI for eggplant and pepper. 0-day PHI for tomato. RUP.

Asana XL® (0.66EC) at 5.8-9.6 fl. oz. per acre. 1-day PHI for tomato. 7-day PHI for eggplant. RUP.

Assail® (30SG) at 1.5-2.5 oz. per acre. 7-day PHI.

Baythroid XL® (1EC) at 1.6-2.8 fl. oz. per acre. 0-day PHI for tomato. 7-day PHI for eggplant. RUP.

Brigade® (2EC) at 2.1-6.4 fl. oz. per acre, or Brigade® (WSB) at 5.3-16 oz. per acre. 7-day PHI for eggplant. 1-day PHI for tomato. RUP.

Confirm® (2F) at 6-16 fl. oz. per acre. 7-day PHI.

Coragen® (1.67SC) at 3.5-5 fl. oz. per acre. 1-day PHI.

Entrust® (2SC) at 1-2 oz. per acre. Observe resistance management restrictions. 1-day PHI.

Exirel® (0.83SE) at 7-13.5 fl. oz. per acre. 1-day PHI.

Intrepid® (2F) at 4-16 fl. oz. per acre. 1-day PHI.

Kryocide® (96D) at 8-16 lbs. per acre. 14-day PHI.

Mustang Maxx® (0.8EC) at 2.24-4.0 fl. oz. per acre. 1-day PHI. RUP.

Platinum® (2SC) at 5-11 fl. oz. per acre. 30-day PHI.

Pounce® (25WP) at 3.2-12.8 oz. per acre. 3-day PHI for eggplant. 0-day PHI for tomato.

Prokil Cyo1ite® (50D) at 15-30.5 lbs. per acre. 14-day PHI.

Radiant® (1SC) at 5-10 fl. oz. per acre. 1-day PHI.

Rimon® (0.83EC) at 9-12 fl. oz. per acre. 1-day PHI.

Sivanto® (200SL) at 10.5-14 fl. oz. per acre. 1-day PHI.

Veri1ark® (1.67SC) via drip chemigation or soil injection at 5-10 fl. oz. per acre. 1-day PHI.

Vydate L® (2WSL) at 2-4 pts. per acre. Do not exceed 32 pts. per acre per season. 3-day PHI for tomato. 1-day PHI for eggplant.

Warrior II® (2.08CS) at 1.28-1.92 fl. oz. per acre. Do not exceed 23 fl. oz. per acre per season. 5-day PHI. RUP.

This is a reduced-risk pesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.
Flea Beetles

**Recommended Products**

- **Actara®** (25WDG) at 2-3 oz. per acre. Do not exceed 11 oz. per acre per season. 0-day PHI.

Admire PRO® (4.6F) at the following rates:

  - **Pepper:** 7.0-14 fl. oz. per acre. Do not exceed 14 fl. oz. per acre per season.
  - **Eggplant and tomato:** 7.0-10.5 fl. oz. per acre. Do not exceed 10.5 fl. oz. per acre per season.

21-day PHI for soil applications. 7-day PHI for foliar applications.

- **Ambush®** (2EC) at 6.4-12.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. 0-day PHI for tomato. 7-day PHI for eggplant and pepper. RUP.

- **Asana XL®** (0.66EC) at 5.8-9.6 fl. oz. per acre. Do not apply more than 67.2 fl. oz. per acre per season. 1-day PHI for tomato. 7-day PHI for eggplant and pepper. RUP.

- **Mustang Maxx®** (0.8EC) at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI. RUP.

- **Platinum®** (2SC) at 5-11 fl. oz. per acre. 30-day PHI.

- **Pounce®** (25WP) at 6.4-12.8 oz. per acre. Pepper and eggplant only. Do not exceed 8 lbs. per acre per season. 3-day PHI. RUP.

- **Sevin XLR PLUS®** (4F) at 0.5-1 qt. per acre. Do not exceed 8 qts. per crop. 3-day PHI.

- **Warrior II®** (2.08CS) at 1.28-1.92 fl. oz. per acre. Do not exceed 23 fl. oz. per acre per season. 5-day PHI. RUP.

Mites, Spider Mites, and Russet Mites

**Recommended Products**

- **Acramite®** (50WS) at 0.75-1 lb. per acre. Spider mites only. Do not exceed 1 application per season. 3-day PHI.

Agri-mek® (0.7SC) at 8-16 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. 7-day PHI. RUP.

Nealta® (1.67SC) at 13.7 fl. oz. per acre. Spider mites on tomato only. Do not exceed 27.4 fl. oz. per acre per crop. 3-day PHI.

- **Oberon®** (2SC) at 7-8.5 fl. oz. per acre. Do not exceed 25.5 fl. oz. per acre per season. 1-day PHI.

- **Portal®** (0.4EC) at 2 pts. per acre. Do not exceed 2 applications per season. 1-day PHI.

Wettable sulfur (84-95%) at 10 lbs. per acre. Sulfur dusts also are effective. Thorough coverage is required. Do not apply when temperatures are above 95°F or during a heavy dew.

- **Zeal®** (72WP) at 2-3 oz. per acre. Spider mites only. Pepper and eggplant only. Limit 1 application per season. 7-day PHI.

Cutworms, Hornworms, Fruitworms, Pinworms and European Corn Borers

**Recommended Products**

- **Ambush®** (2EC) at 3.2-12.8 fl. oz. per acre. 3-day PHI for eggplant and pepper. 0-day PHI for tomato.

- **Asana XL®** (0.66EC) at the following rates:
  - **Cutworms, pinworms and fruitworms:** 5.8-9.6 fl. oz. per acre.
  - **Hornworms:** 2.9-5.8 fl. oz. per acre.

Not for European corn borers. Do not apply more than 0.35 lb. a.i. per acre per season. 1-day PHI for tomato. 7-day PHI for eggplant and pepper. RUP.

- **Avaunt®** (30WDG) at 2.5-3.5 oz. per acre. Not for cutworms. Use higher rate for fruitworms. Can control European corn borer in bell pepper only. Do not exceed 14 oz. per acre per season. 3-day PHI.

- **Various Bacillus thuringiensis** products (Agree®, Bio-Bit®, Dipel®, Javelin®, Lepinox®, Xentari®). Follow label directions. Not for cutworms or pinworms. 0-day PHI.

- **Baythroid XL®** (1EC) at 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. 0-day PHI for tomato. 7-day PHI for eggplant and pepper. RUP.

- **This is a reduced-risk pesticide. See page 37 for details.**

- **This is a biopesticide. See page 37 for details.**
**Fruiting Vegetables - Insect Control**

**Brigade**® (2EC) at 2.1-5.2 fl. oz. per acre, or **Brigade**® (WSB) at 5.3-12.8 oz. per acre. **Eggplant**: Do not exceed 0.2 lb. a.i. per acre per season. 7-day PHI. **Tomato**: Do not exceed 4 applications per season. 1-day PHI. **RUP**.

**Coragen**® (1.67SC) at 3.5-5.0 fl. oz. per acre. **Coragen**® can be applied as either a foliar application or via drip chemigation. Chemigation will provide up to 30 days control. Do not exceed 15.4 fl. oz. per acre per season. 1-day PHI. **RUP**.

**Danitol**® (2.4EC) at 10.67 fl. oz. per acre. **Not for cutworms or European corn borers**. Do not exceed 42.67 fl. oz. per acre per season. 3-day PHI. **RUP**.

**Diazinon AG500**® (4EC) at 2-4 qts. per acre. **Apply before planting**. **Cutworms on tomato only**. Do not exceed 1 application per season. 1-day PHI. **RUP**.

**Exirel**® (0.83SE) at 7-13.5 fl. oz. per acre. 1-day PHI. **RUP**.

**Mustang Maxx**® (0.8EC) at 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI. **RUP**.

**Permethrin**® (3.2EC) at 6.4-12.8 oz. per acre. Do not exceed 8 lbs. per acre per season. 3-day PHI for pepper and eggplant. 0-day PHI for tomato. **RUP**.

**Radiant**® (1SC) at 5-10 fl. oz. per acre. **Not for cutworms**. Do not exceed 34 fl. oz. per acre per season. 1-day PHI. **RUP**.

**Sevin XLR PLUS**® (4F) at 1-2 qts. per acre. Do not exceed 8 qts. per acre per season. 3-day PHI. **RUP**.

**Verimark**® (1.67SC) via drip chemigation or soil injection at 5-10 fl. oz. per acre. **Use maximum rate for European corn borer**. 1-day PHI. **RUP**.

**Warrior II**® (1.08CS) at the following rates:

- **Cutworms and hornworms**: 0.96-1.6 fl. oz. per acre.
- **Fruitworms and pinworms**: 1.28-1.92 fl. oz. per acre.

Do not exceed 23 fl. oz. per acre per season. 5-day PHI. **RUP**.

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### Stink Bugs (including Marmorated Stink Bug)

**Recommended Products**

**Baythroid XL**® (1EC) at 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. Allow 7 days between applications. 0-day PHI for tomato. 7-day PHI for pepper and eggplant. **RUP**.

**Belay**® (2.13SC) at 3-4 fl. oz. per acre. 7-day PHI for eggplant and tomato. 1-day PHI for pepper. **RUP**.

**Brigade**® (2EC) at 2.1-5.2 fl. oz. per acre, or **Brigade**® (WSB) at 5.3-12.8 oz. per acre. **Eggplant**: Do not exceed 12.8 fl. oz. of 2EC per acre per season; do not exceed 32 oz. of WSB per acre per season. 7-day PHI. **Tomato**: Do not exceed 4 applications per season. 1-day PHI. **RUP**.

**Danitol**® (2.4EC) at 10.67 fl. oz. per acre. **Tomato only**. Do not exceed 42.67 fl. oz. per acre per season. 3-day PHI. **RUP**.

**Mustang Maxx**® (0.8EC) at 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. Allow 7 days between applications. 1-day PHI. **RUP**.

**Venom**® (SG70) at the following rates:

- **Foliar applications**: 3-4 oz. per acre. 1-day PHI.
- **Soil applications**: 5-6 oz. per acre. 21-day PHI.

**Warrior II**® (2.08CS) at 1.28-1.92 fl. oz. per acre. Do not exceed 23 fl. oz. per acre per season. 5-day PHI. **RUP**.

### Whiteflies

**Recommended Products**

**Actara**® (25WDG) at 3.0-5.5 oz. per acre. Do not exceed 11.0 oz per acre per season. 0-day PHI. **RUP**.

**Admire PRO**® (4.6F) at the following rates:

- **Soil-applied to pepper**: 7.0-14 fl. oz. per acre. Do not exceed 14 fl. oz. per acre per season.
- **Soil-applied to eggplant and tomato**: 7.0-10.5 fl. oz. per acre. Do not exceed 5 fl. oz. per acre per season.
- **Foliar applications**: 1.3-22 fl. oz. per acre.

21-day PHI for soil applications. 0-day PHI for foliar applications. **May be acceptable for use in certified organic production. Check with your certifier before use.**

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This is a reduced-risk pesticide. See page 37 for details. **RUP**.
Asana XL* (0.66EC) at 5.8-9.6 fl. oz. per acre. *Not for eggplant. Do not apply more than 67.2 fl. oz. per acre per season. 1-day PHI for tomato. 7-day PHI for pepper. RUP.

**Assail**® (30SG) at 2.5-4 oz. per acre. Do not exceed 4 applications per season. 7-day PHI.

**Brigade**® (2EC) at 2.1-5.2 fl. oz. per acre, or **Brigade**® (WSB) at 5.3-12.8 oz. per acre. *Eggplant: Do not exceed 12.8 fl. oz. of 2EC per acre per season; do not exceed 32 oz. of WSB per acre per season. *Tomato: Do not exceed 4 applications per season. 1-day PHI. RUP.

**Danitol**® (2.4EC) at 7-10.67 fl. oz. per acre. *Tomato only. Do not exceed 42.67 fl. oz. per acre per season. 3-day PHI.

**Exirel**® (0.83SE) at 13.5-20.5 fl. oz. per acre. 1-day PHI.

**Fulfill**® (50WDG) at 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. 0-day PHI.

**Knack**® (0.86EC) at 8-10 fl. oz. per acre. Do not exceed 2 applications per acre per season. 14-day PHI.

**Movento**® (2SC) at 4-5 fl. oz. per acre. 1-day PHI.

**M-Pede**® at 1-2% by volume. Must contact whiteflies to be effective. 0-day PHI.

**Neemix**® according to label directions. 0-day PHI.

**Oberon**® (2SC) at 7-8.5 fl. oz. per acre. Do not exceed 25.5 fl. oz. per acre per season. 1-day PHI.

**Platinum**® (2SC) at 5-11 fl. oz. per acre. No more than 1 application per season. 30-day PHI.

**Sivanto**® (200SL) at the following rates:

- **Foliar applications:** 10.5-14 fl. oz. per acre. 1-day PHI.
- **Soil applications:** 21-28 fl oz per acre. 45-day PHI.

**Verimark**® (1.67SC) via drip chemigation or soil injection at 6.75-10 fl. oz. per acre. 1-day PHI.

### Fruit Flies and Vinegar Flies (*Drosophila spp.*)

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 with dust fruit and hampers as soon as filled with a dust containing 0.1% stabilized pyrethrins plus 1.0% piperonyl butoxide, and move hampers to processing plant as soon as possible.

*This is a reduced-risk pesticide. See page 37 for details.*

*May be acceptable for use in certified organic production. Check with your certifier before use.*

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Producing vegetables in high tunnels allows growers to extend the growing season and exploit new market windows.
Leafy Vegetables

Endive, Herbs, Lettuce, Parsley, and Spinach

Disease Control

Botrytis Gray Mold
In greenhouse production, avoid condensation on foliage by providing adequate ventilation within the enclosure and avoiding overcrowding plants.

Recommended Products
Botran 75W® or Botran 5F® at planting. Rate depends on crop and application method. *Lettuce and endive only.*

Cannonball WG® at 7 oz. per acre. 0-day PHI.

Endura® 8-11 oz. per acre. 14-day PHI. *Lettuce only.*

Fontelis® at 14-24 fl. oz. per acre. 3-day PHI.

Merivon® at 8-11 fl. oz. per acre. 1-day PHI.

Switch 62.5WG® at 11-14 oz. per acre. 0-day PHI.

Damping-off
Conditions that favor rapid germination limit damping-off severity. Avoid excessive irrigation and poorly drained soils. Good sanitation is critical to avoiding damping-off.

Recommended Products
Previcur Flex® See label for rates and greenhouse uses.

For damping-off of lettuce caused by Pythium and Phytophthora.

Ridomil Gold SL® at 1-2 pts. per acre applied pre-plant, to control damping-off.

Downy Mildew, White Rust
Plant downy mildew-resistant varieties.

Recommended Products
Actigard® at the following rates:

Spinach: 0.5-0.75 oz. per acre.

Lettuce: 0.75-1 oz. per acre. *Downy mildew only.*

Not for herbs. 7-day PHI.

Agri-Fos 50WP® See label for rates. *Not for herbs. Downy mildew only.* 0-day PHI.

Dithane F-45® at 1.2-1.6 qts. per acre. *Downy mildew on lettuce only.* 10-day PHI for head lettuce. 14-day PHI for leaf lettuce.

Spaing
These crops can have a common between-row spacing for convenience in cultivating.

Spinach: Rows 12 to 18 inches apart. Plants 4 to 6 per foot of row. Seed 12 to 20 pounds per acre.

Lettuce and Endive: Rows 12 to 15 inches apart. Plants 10 to 16 inches apart in row. Seed 1 to 2 pounds per acre.

Fertilizing

Lime: To maintain soil pH of 6.5 to 6.8. Spinach is particularly sensitive to soil acidity.

Preplant: N: 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.

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.

This is a reduced-risk pesticide. See page 37 for details.

Varieties

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<td>Spinach</td>
<td>Bloomsdale Long Standing (spring), Early Hybrid No. 7 (fall), Early Hybrid No. 10 (fall), Old Dominion (fall), Virginia Savoy (fall), Tyee, Melody, Decatur, Unipak 151 (semi-savoy)</td>
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</tr>
</tbody>
</table>
Merivon® at 4-11 fl. oz. per acre. *Downy mildew suppression only. 1-day PHI.

Phostrol® at 2.5-5 pts. per acre. *Downy mildew only. 0-day PHI.

Presidio 4SC® at 3-4 fl. oz. per acre. 2-day PHI.

Previcur Flex® at 2 pts. per acre. *Lettuce and downy mildew only. 2-day PHI.

Quadris® at the following rates:
   *Downy mildew: 12.0-15.5 fl. oz. per acre.
   *White rust: 6.2-15.4 fl. oz. per acre.
   0-day PHI.

Ranman® at 2.75 fl. oz. per acre. 0-day PHI.

Revsus 2.09SC® at 8 fl. oz. per acre. *Downy mildew on lettuce and spinach only. 1-day PHI.

Ridomil Gold SL® at 0.25 pt. per acre. *Spinach only. 7-day PHI.

Satori® at the following rates:
   *Downy mildew: 12.0-15.5 fl. oz. per acre.
   *White rust: 6.2-15.4 fl. oz. per acre.
   0-day PHI.

Tanos 50WP® at 8-10 oz. per acre. *Not for herbs. 1-day PHI.

Zampro® at 14 fl. oz. per acre. *Downy mildew only. Do not use with herbs except for fennel. 0-day PHI.

**Bottom Rot and Drop (lettuce)**

Bottom rot is caused by *Rhizoctonia*. Lettuce drop is caused by *Sclerotinia*. Avoid poorly drained fields with a history of the disease.

**Recommended Products**

Botran 75W® or Botran 5F®. Rate varies by application method. *Lettuce drop only.*

Contans®. See label for rate and application instructions. *Lettuce drop only.*

Cannonball WG®. at 7 oz. per acre. See label for soil application instructions. *Lettuce drop only. 0-day PHI.*

Endura 70WG® at 8-11 oz. per acre. *Lettuce only. Bottom rot is suppression. 14-day PHI.*

Fontelis® at 16-24 fl. oz. per acre. *Lettuce drop only. 3-day PHI.*

Merivon® at 8-11 fl. oz. per acre. *Lettuce drop only. 1-day PHI.*

**Lettuce Mosaic Virus (LMV)**

This virus can be carried in infested seed and is spread by aphids. Sow only mosaic-free indexed seed (sold as MTO). Control aphids and weeds near to production areas. Keep new lettuce planting as far as possible from old lettuce plantings. Disk under lettuce fields as soon as possible after final harvest.

**Weed Control**

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 weeder, 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 Table 25 on page 66.

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).
Leafy Vegetables - Weed Control

Weed Control for Herbs and Lettuce (General)

Recommendations for specific crops are provided below.

Preemergence Broadleaves and Grasses

Recommended Products

Devrinol® at 2-4 lbs. per acre. Basil, marjoram, rosemary, and savory only. Apply before or after seeding and incorporate into soil, or water-in with 0.2-0.4 inch of water. 0-day PHI.

Prefar 4E® at 5-6 qts. per acre. Endive, escarole, cress, fennel, lettuce, and parsley only. Mineral soils only. Apply and incorporate before seeding or apply after seeding and incorporate with irrigation.

Postemergence Broadleaves

Recommended Product

Aim 2EC® at 1-2 fl. oz. per acre. Basil, chive, dill, fennel, parsley, and rosemary only. Apply as a burndown treatment at least 7 days before seeding. 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. 0-day PHI.

Postemergence Grasses

Recommended Product

Select Max 0.97E® at 9-16 fl. oz. per acre. Basil, borage, chive, dill, coriander, parsley, tarragon, and thyme only. Apply to actively growing grasses. Try on a small area before spraying field. 14-day PHI.

Postemergence Broadleaves and Grasses

Recommended Product

Scythe 4.2L® at 5-10 gals. per acre. Basil, chive, dill, fennel, oregano, savory, tarragon, and thyme only. Apply as a directed or hooded spray between rows in 75-200 gals. of water per acre. Use higher rate for large and mature weeds.

Weed Control for Basil

Recommended Products

Aim® at 2-4 fl. oz. per acre. Postemergence broadleaves. Apply to area between rows with a hooded sprayer. Do not exceed 6 fl. oz. per acre per year. 0-day PHI.

Devrinol 50DF-XT® at 2-4 lbs. per acre. Preemergence annual grasses and some small-seeded broadleaves. Apply before or after seeding and incorporate into soil, or water-in with 0.2-0.4 inch irrigation. 0-day PHI.

Roundup 4L® at 0.5-1 qt. per acre. Postemergence annual and perennial weeds. Apply before planting.

Scythe 4.2L® at 5-10 gals. per acre. Postemergence grasses and broadleaves. Apply as a directed or hooded spray between rows in 75-200 gals. of water per acre. Use higher rate for large weeds.

Select Max® at 9-16 fl. oz. per acre. Apply to actively growing grasses. Include nonionic surfactant at 0.25%. Do not exceed 64 fl. oz. per acre per year. 14-day PHI.

Weed Control for Celeriac

Recommended Products

Caparol 4L® at 1.6-4 pts. per acre. Preemergence. Apply after transplanting to crop with 6-8 leaves. Use low rate on light soil. 60-day PHI.

Lorox 50DF® at 1.5-3 lbs. per acre. Postemergence grasses and broadleaves. Apply after transplanting as a broadcast spray. Do not add surfactants, nitrogen (or other fertilizers), or other pesticides to the spray mix. 60-day PHI.

Weed Control for Chive

Recommended Products

Dual Magnum 7.62EC® at 0.67-1.33 pts. per acre. Preemergence. Growers in Michigan must have a 24(c) label. Make broadcast application at 2-3 crop leaf stage. Do not exceed 1 application and 1.33 pts. per acre per season. 21-day PHI.

Prowl H2O 3.8ACS® at 2-4 pts. per acre. Preemergence annual grasses and broadleaves. Growers in Michigan must have a 24(c) label. Use high rate pre on high-organic soil. Apply to chives after seeding, or at the 2-3 leaf stage to control germinating annual grasses and weeds. Will not control emerged weeds. Do not exceed 4 pts. per acre per year. 30-day PHI.

Select Max 0.97E® at 9-16 fl. oz. per acre. Postemergence grasses. Apply to actively growing grasses and include an adjuvant. Use high rate on annual bluegrass. 14-day PHI.

Weed Control for Cilantro

Recommended Products

Caparol 4L® at 1-3.2 pts. per acre. Preemergence. Do not use on sand or loamy sand soil. Make 1 application after seeding. Higher rates may reduce crop stand. 30-day PHI.
Dual Magnum 7.62E® at 0.67-1 pt per acre. Preemergence annual grasses and broadleaves. Growers in Michigan must have a 24(c) label. Apply to soil surface after seeding. Do not exceed 1 pt. per acre per year. 30-day PHI.

Lorox 50DF® at 1-2 lbs. per acre.

Preemergence: Apply after seeding and before crop emergence. Use lower rate on sandy soil. Do not apply to soil <1% organic matter.

Postemergence: Make up to 2 postemergence applications at 1-2 lbs. per acre after cilantro has 3 true leaves.

Do not exceed 4 lbs. per acre per year. 21-day PHI.

Select Max 0.97E® at 9-16 fl oz per acre. Postemergence grasses. Apply to actively growing grasses. Include NIS at 0.25% v/v of spray solution. Do not exceed 64 fl. oz. per acre per year. 14-day PHI.

Recommended Products

Caparol 4L® at 1.6-3.2 pts. per acre. Preemergence or postemergence. Use a lower rate on sandy soil. 30-day PHI.

Balan 60DF® at 2-2.5 lbs. per acre. Apply and incorporate before seeding or transplanting.

Kerb 3.3SC® at 2.5-5 pts. per acre. Preemergence grasses and small-seeded broadleaves. Apply before or after seeding. Must be incorporated or irrigated into soil. Can be applied postemergence, but weed control will be marginal on muck soil. 55-day PHI. RUP.

Poast 1.5E® at 1-1.5 pts. per acre. Postemergence grasses. Apply to actively growing grasses. Include 1 qt. COC per acre. Do not exceed 3 pts. per acre per season. 5-day PHI.

Prefar® at 5-6 qts. per acre. Preemergence grasses. Endive, florence fennel, and radicchio only. Apply before planting and incorporate or water in.

Roundup 4L® at 2-3 qts. per acre. Postemergence perennials. Apply before planting in the spring or after harvest in the fall. Check label for best time of year, stage of growth, and rate for each weed. Include 1 pt. NIS per acre.

Select Max 0.97E® at 9-16 fl. oz. per acre. Include 0.25% NIS v/v of spray solution per acre. Do not exceed 64 fl. oz. per acre per year. 14-day PHI.

Treflan 4EC® at 1-2 pts. per acre. Preemergence grasses and small-seeded broadleaves. Belgian endive, endive, escarole, chicory, and radicchio only. Incorporate before seeding.

Recommended Products

Aim® at 2 fl. oz. per acre. Postemergence broadleaves. 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.

Kerb 3.3SC® at the following rates:

Muck soils with >20% organic matter: 4.8-7.2 qts. per acre

All other soils: 1.25-5 pts. per acre.

All lettuce. Growers in Michigan must have a 24(c) label. Apply before or after seeding but before weeds emerge. Incorporate or irrigate into the soil. Can be applied postemergence to lettuce. 55-day PHI. RUP.

Prefar® at 5-6 qts. per acre. Apply preplant and incorporate or preemerge and water in. Not effective on muck soil.
**Postemergence Grasses**

**Recommended Products**

*Poast 1.5E* at 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. 30-day PHI for head lettuce. 15-day PHI for leaf lettuce.

*Select Max* at 9-16 fl. oz. per acre. Include 0.25% NIS/acre. Do not exceed 64 fl. oz. per acre per year. 14-day PHI.

**Postemergence Broadleaves**

**Recommended Product**

*Aim 2EC* at 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.

**Weed Control for Parsley**

**Recommended Products**

*Aim* at 1-2 fl. oz. per acre. *Postemergence broadleaves.* Apply as a burndown treatment at least 7 days before seeding. 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. 0-day PHI.

*Caparol 4L* at 1-4 pts. per acre. *Preemergence and postemergence broadleaves and grasses.* 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.

*Lorox 50DF* at the following rates:

- *Preemergence on mineral or muck soils:* 1-3 lbs. per acre. Use low rate on coarse soils
- *Postemergence on muck soils only:* 1 lb. per acre. Do not apply after parsley has 3 true leaves.

**Weed Control for Spinach**

**Preemergence Broadleaves and Grasses**

**Recommended Products**

*Dual Magnum 7.62E* at 0.33-1.0 pt. per acre. Indiana, Ohio, and Michigan only. Apply to soil surface after planting. Do not incorporate. Use low rate on sandy soil. 50-day PHI.

*Ro-Neet 6E* at 1.4-2 qts. per acre. *Mineral soil only.* Growers in Michigan must have a 24(c) label. Apply before planting and immediately incorporate 2-3 inches. 45-day PHI.

**Postemergence Grasses**

**Recommended Product**

*Poast 1.5E* at 1-1.5 pts. per acre. *Postemergence grasses.* Apply to actively growing grasses. Include 1 qt. COC per acre. Do not exceed 3 pts. per acre per year. 15-day PHI.

*Select Max 0.97E* at 9-16 fl. oz. per acre. Include 0.25% NIS v/v spray solution per acre. Do not exceed 64 fl. oz. per acre per year. 14-day PHI.

**Weed Control for Swiss Chard**

**Recommended Products**

*Dual Magnum 7.62E* at 0.5-1 pts. per acre. *Preemergence.* Michigan only. Apply after seeding. Use lowest rate on light soils. Do not exceed 64 fl. oz. per acre per season. 15-day PHI.

*Poast 1.5E* at 1-1.5 pts. per acre. *Postemergence grasses.* Apply to actively growing grasses. Include 1 qt. of COC per acre. Do not exceed 3 pts. per acre per year. 15-day PHI.

*Select Max 0.97E* at 9-16 fl. oz. per acre. Include 0.25% NIS v/v spray solution per acre. Do not exceed 64 fl. oz. per acre per year. 14-day PHI.
## Herbicides for Leafy Vegetables

<table>
<thead>
<tr>
<th>Product (REI PHI)</th>
<th>Common Name</th>
<th>Timing and Application Location Relative to Crop</th>
<th>Incorporated</th>
<th>Timing Relative to Weeds</th>
<th>Weed Groups Controlled</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before Seeding</td>
<td>After Seeding</td>
<td>Before Transplanting</td>
<td>Post Emergence - Between Rows Only</td>
<td>Postemergence</td>
</tr>
<tr>
<td>Aim EC (12h)</td>
<td>carfentrazone</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Balan 60DF (12h/-)</td>
<td>benefin</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Caparol</td>
<td>promatyan</td>
<td>X</td>
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<tr>
<td>Devinol (100)</td>
<td>Napropamide</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Dual Magnum (24h/50d to 60d)</td>
<td>s-metolachlor</td>
<td>X</td>
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<tr>
<td>Gramoxone Inteon 2L (12h to 24h)</td>
<td>paraquat</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Kerb 50WP (24h/55d)</td>
<td>pronamide</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Lorox 50DF (24h/50d)</td>
<td>linuron</td>
<td>X</td>
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<tr>
<td>Poast (12h/14d to 30d)</td>
<td>sethoxydim</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Prefar 4E (12h/-)</td>
<td>bensulide</td>
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<tr>
<td>Raptor</td>
<td>Imazamox</td>
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<tr>
<td>Reflex (30 dphi)</td>
<td>Fomesafen</td>
<td>X</td>
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<tr>
<td>Roundup, others (12h/14d)</td>
<td>glyphosate</td>
<td>X</td>
<td>X</td>
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<td>Scythe</td>
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<tr>
<td>Select Max, others (12h/14d to 32 d)</td>
<td>clethodim</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Spin-Aid (12h/40d)</td>
<td>phenmediphan</td>
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<td>X</td>
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<td>Stinger (12h/21d)</td>
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<td>X</td>
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<tr>
<td>Treflan, others (12h/-)</td>
<td>trifluralin</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tbody>
</table>

1=For effectiveness against specific weeds, see Table 25 on page 66, 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=may be used for that crop. *=Processing crops only.
Insect Control

Aphids, Leafminers, Mites
Treat when insects reach the economic thresholds described below.

Seedlings
Aphids
2 per plant
Leafminers
50% of plants infested

Established Plants
Aphids
7 per plant

Near Harvest
Leafminers
5% of leaves infested

Recommended Products
Acramite® (4SC) at 12-24 fl. oz. per acre, or Acramite® (50WS) at 0.75-1.5 lb. per acre. 7-day PHI.

Actara® (25WDG) at 1.5-3 oz. per acre. Aphids only. Do not exceed 11 oz. per acre per season. 7-day PHI.

Admire PRO® (4.6F) at the following rates:
Soil applications for aphids only: 4.4-10.5 fl. oz. per acre. Do not exceed 10.5 fl. oz. per acre per season. See label for application methods. 21-day PHI.

Foliar applications for aphids only: 1.3 fl. oz. per acre. Do not exceed 6.5 fl. oz. per acre per season. 7-day PHI.

Agri-Mek® (0.15EC) at 8-16 fl. oz. per acre, or Agri-Mek® (SC) at 1.75 to 3.5 fl. oz. per acre. Leafminers and mites only. Do not exceed 2 applications and 48 fl. oz. per acre per season. Use with NIS adjuvant. Do not use binder or sticker-type surfactants. 14-day PHI for all herbs except chives. 7-day PHI for chives and all other crops. RUP.

Ambush® (25W) at 6.4-12.8 oz. per acre. Leafminers only. Spinach: Do not exceed 1 lb. a.i. per acre per season. All others: Do not exceed 2 lbs. per acre per season. 1-day PHI. RUP.

Assail® (30SG) at 2-4 oz. per acre, or Assail® (70WP) at 0.8-1.7 oz. per acre. Aphids only. Do not exceed 20 oz. of 30SG per acre per season. Do not exceed 8.5 oz. of 70WP per acre per season. 7 -day PHI.

Belay® (2.13SC) at the following rates:
Soil applications: 9-12 fl. oz. per acre. Aphid and leafminer suppression only. Do not exceed 10.5 fl. oz. per acre per season. See label for application methods. 21-day PHI.

Foliar applications: 3-4 fl. oz. per acre. Aphids only. Do not exceed 12 fl. oz. per acre per season. 7-day PHI.

Belay® (50WDG) at the following rates:
Soil applications: 4.8-6.4 fl. oz. per acre. Aphid and leafminer suppression only. Do not exceed 6.4 fl. oz. per acre per season. See label for application methods.

Foliar applications: 1.6-2.1 fl. oz. per acre. Aphids and leafminers (suppression only). Do not exceed 6.4 fl. oz. per acre per season. 7-day PHI.

Beleaf® (50SG) at 2-2.8 oz per acre. Aphids only. Do not exceed 8.4 oz. (0.267 lbs. a.i.) per acre per season. 0-day PHI.

Brigade® (2EC) at the following rates
Aphids on head lettuce, cilantro, coriander: 2.1-6.4 fl. oz. per acre. 3-day PHI for cilantro and coriander. 7-day PHI for lettuce.

Mites on lettuce and spinach: 5.12-6.4 fl. oz. per acre. 7-day PHI for lettuce. 40-day PHI for spinach.

Do not exceed 2 1/8 lbs. a.i. per acre per season. RUP.

Brigadier® (50SG) (RUP) at the following rates:
Aphids on coriander and cilantro only: 4.24-5.5 fl. oz. per acre. Do not exceed 16.64 fl. oz. (0.13 lb. a.i.) per acre per acre of Imidacloprid and 0.13 lb active ingredient per acre of bifenthrin) per season. 7-day PHI.

Aphids on head lettuce only: 3.8-6.1 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season (0.24 lb. a.i. of imidacloprid and 0.24 lb. a.i. of bifenthrin). 7-day PHI.

Aphids on spinach only: 3.8-6.14 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season (0.24 lb. a.i. of imidacloprid and 0.24 lb. a.i. of bifenthrin). 40-day PHI.

Leafminers (suppression only): 5.1-6.14 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season (0.24 lb. a.i. of imidacloprid and 0.24 lb. a.i. of bifenthrin). 40-day PHI.

This is a reduced-risk pesticide. See page 37 for details.
Capture® (LFR) at 3.4-6.8 fl. oz per acre. Lettuce root aphid and bulb mites on head lettuce only. 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). RUP.

Dimethoate® (4E) at 0.5 pt. per acre. Not for parsley, spinach, celery, or head lettuce. 14-day PHI for endive, Swiss chard, and leaf lettuce.

Entrust® (2SC) at 6-10 fl. oz per acre. Leafminers only. Do not exceed 29 fl. oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

Fulfill® (50WDG) at 2.75 oz. per acre. Aphids only. Do not exceed 5.5 oz. per acre per season. 7-day PHI.

Hero® at the following rates:

- Aphids and leafminers (adults): 4-10.3 oz. per acre.
- Carmine mite, Pacific spider mite, and two-spotted spider mite on head lettuce only: 10.3 oz. per acre.
- Do not exceed 46.35 oz. (0.45 lb. a.i.) per acre per season. Observe resistance management restrictions. 7-day PHI. RUP.

Hero EW® at the following rates:

- Aphids and leafminers (adults): 4.5-11.2 oz. per acre.
- Carmine mite and two-spotted spider mite on head lettuce only: 11.2 oz. per acre.
- Do not exceed 50.5 oz. (0.45 lb. a.i.) per acre per season. Observe resistance management restrictions. 7-day PHI. RUP.

Malathion® (5EC) at 1-3 pts. per acre depending on crop and pest (see label for rates). Aphids and mites only. 14-day PHI for leaf and head lettuce and Swiss chard. 7-day PHI for endive and spinach.

Mehisto® (2SC) at 4-5 fl. oz. per acre. Aphid and leafminer suppression only. Must be tank-mixed with a spray adjuvant/additive that has spreading and penetrating properties to maximize leaf uptake and systemicity of the active ingredient within treated plants. 3-day PHI.

M-Pede® at 1-2% by volume. Leafminer suppression on herbs or aphids only. Must contact aphids to be effective. Avoid spraying under hot conditions to minimize potential for plant injury. 0-day PHI.

Neemix 4.5® at 4-7 fl. oz. per acre. Leafminers only. 0-day PHI.

Orthene® (97S) at 8-16 oz. per acre. Aphids on head lettuce (crisphead type) only. Do not exceed 2 1/8 lbs. a.i. per acre per season. 21-day PHI.

Platinum® (2SC) at 5-11 fl. oz. per acre in-soil applications. Aphid and leafminer suppression only. See label for application methods. Do not exceed 11 fl. oz. a.i. per acre per season. 30-day PHI.

Permethrin® (3.2EC) at 4-8 fl. oz. per acre. Leafminers on spinach: Do not exceed 24 fl. oz. per acre per season. Lettuce: Do not exceed 32 fl. oz. per acre per season. 1-day PHI. RUP.

Radiant® (1SC) at 6-10 fl. oz. per acre. Leafminers only. Do not exceed 34 fl. oz. (0.266 lb. a.i. spinetoram) per acre per season. 1-day PHI.

Sivanto® (200SL) at 10.5-12 fl. oz. per acre. Aphids only. Do not exceed 28 fl. oz. per acre per season. 1-day PHI.

Torac® (1.29EC) at 17-21 fl. oz. per acre. Aphids only. Do not exceed 2 applications per season. 1-day PHI.

Trigard® (75WP) at 2.66 oz. per acre. Leafminers only. Do not exceed 6 applications per acre per season. 7-day PHI.

Venom® (70SG) for green peach aphid and potato aphid suppression only at the following rates:

- Foliar applications: 1-3 fl. oz. per acre. 7-day PHI.
- Soil applications: 5-6 fl. oz. per acre. 21-day PHI.

Carrot Weevil

For parsley, scout plants at the 4-leaf stage, looking for ovipunctures (egg-laying scars) on the stems. Treat if ovipunctures are found on at least 1% of plants.

Recommended Products

Baythroid XL® (1EC) at 3.2 fl. oz. per acre. 0-day PHI.

Malathion 5EC® at 1.5-2.4 pts. per acre. 7-day PHI for parsley.
Leafy Vegetables - Insect Control

Caterpillars (including cutworms and armyworms), Loopers
Treat when 5% of plants are infested.

Recommended Products

Ambush® (25W) at 6.4-12.8 oz. per acre. Spinach: Do not exceed 1 lb. a.i. per acre per season. All others: Do not exceed 2 lbs. a.i. per acre per season. 1-day PHI. RUP.

Avaunt® (30WDG) at the following rates:

Spinach: 3.5 oz. per acre. Do not exceed 14 oz. per acre per season.

Other labeled crops: 2.5-6.0 oz. per acre. Do not exceed 24 oz. per acre per season.

3-day PHI.

Various Bacillus thuringiensis products (Agree®, Bio-bit®, Dipel®, Javelin®, Xentari®) are available in various formulations. Follow label instructions for rates and use. 0-day PHI.

Baythroid XL® (1EC) at the following rates:

Cutworms: 0.8-1.6 fl. oz per acre.
Cabbageworm and loopers: 1.6-2.4 fl. oz. per acre.
Armyworms, corn earworm, and European corn borer: 2.4-3.2 fl. oz. per acre.

Do not exceed 12.8 fl. oz. per acre per season. Allow 7 days between applications. 0-day PHI. RUP.

Brigade® (2EC) at 2.1-6.4 fl. oz. per acre, or Brigade® (WSB) at 5.3-16 oz. per acre. Head lettuce and spinach only. Head lettuce: Do not exceed 1 qt. of 2EC per acre per season. Do not exceed 80 oz. of WSB per acre per season. 7-day PHI. Spinach: Do not exceed 25.6 fl. oz. of 2EC per acre per season. Do not exceed 64 oz. WSB per acre per season. 40-day PHI. RUP.

Brigadier® (50SG) at the following rates:

Cabbage looper and cutworm on coriander and cilantro: 4.24-5.5 fl. oz. per acre. Do not exceed 16.64 fl. oz. (0.13 lb. a.i. of imidacloprid and 0.13 lb. a.i. of bifenthrin) per acre per season. 7-day PHI.

Imported cabbageworm, armyworms, cutworms, loopers, and corn earworm on head lettuce: 5.1-6.1 fl. oz. per acre. Do not exceed 30.72 fl. oz. (0.24 lb. a.i. of imidacloprid and 0.24 lb. a.i. of bifenthrin) per acre per season. 40-day PHI. RUP.

Capture® (LFR) at 3.4-6.8 fl. oz. per acre. 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). RUP.
Confirm® (2F) at the following rates:

*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. of product per season. 7-day PHI.

Coragen® (1.67SC) at 3.5-5 fl. oz. per acre. 1-day PHI.

Entrust® (2SC) at 3-6 fl. oz. per acre. Do not exceed 29 oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

Exirel® (0.83SE) at the following rates:

*Armyworms, diamondback moth, and corn earworm:* 7-13.5 fl. oz. per acre. Observe resistance management restrictions for diamondback moth.

*Cabbage looper:* 10-17 fl. oz. per acre.

Do not use adjuvants in tank mix in spinach. Do not exceed 0.4 lb. a.i. per acre per season. 1-day PHI. 21-day PHI. RUP.

Intrepid® (2F) at the following rates:

*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. 1-day PHI. 7-day PHI. 21-day PHI. RUP.

R Gastron® (3.2EC) at 2-8 fl. oz. per acre. *Spinach:* Do not exceed 24 fl. oz. per acre per season. *Lettuce:* Do not exceed 32 fl. oz. per acre per season. 1-day PHI. RUP.

Radiant® (1SC) at 5-10 fl. oz. per acre. *Not for yellowstriped armyworm or western yellowstriped armyworm.* Do not exceed 34 fl. oz. (0.266 lb. a.i. of spinetoram) per acre per season. 1-day PHI.

**Flea Beetles, Leafhoppers**

**Flea Beetle Threshold**

*Seedlings:* >50% plants infested and defoliation > 30%

**Recommended Products**

Actara® (25WDG) at 1.5-3.0 oz. per acre. Do not exceed 11 oz. per acre per season. 7-day PHI.

Admire PRO® (4.6F) at the following rates:

*Soil applications for leafhoppers only:* 4.4-10.5 fl. oz. per acre. See label for application methods. Do not exceed 10.5 fl. oz. (0.38 lb. a.i.) per acre per season. 21-day PHI.

*Foliar applications:* 1.3 fl. oz. per acre. Do not exceed 6.5 fl. oz. (0.23 lb. a.i.) per acre per season. 7-day PHI. RUP.

Ambush® (25W) at 6.4-12.8 oz. per acre. *Leafhoppers only.* *Spinach:* Do not exceed 4 lbs. per acre per season. *All others:* Do not exceed 8 lbs. per acre per season. 1-day PHI. RUP.

Ammo® (2.5EC) at 2.5-5.0 fl. oz. per acre. *Head lettuce only.* Do not exceed 30 fl. oz. per acre per season. 5-day PHI. RUP.

Baythroid XL® (1EC) at the following rates:

*Flea beetles:* 2.4-3.2 fl. oz. per acre.

*Potato leafhoppers:* 0.8-1.6 fl. oz. per acre.

Do not exceed 12.8 fl. oz. per acre per season. Must wait 7 days between applications. 0-day PHI. RUP.

Belay® (2.1SC) at 3-4 fl. oz. per acre. 7-day PHI.

Brigade® (2EC) at 2.1-6.4 fl. oz. per acre, or Brigade® (WSB) at 5.3-16 oz. per acre. *Head lettuce and spinach only.* 7-day PHI for head lettuce. 40-day PHI for spinach. RUP.

This is a reduced-risk pesticide. See page 37 for details.

This is a biopesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.

**Leafy Vegetables - Insect Control**
Brigadier® (50SG) at the following rates:

- Coriander and cilantro: 4.24-5.5 fl. oz. per acre. Do not exceed 16.64 fl. oz. (0.13 lb. a.i. of imidacloprid and 0.13 lb. a.i. of bifenthrin) per acre per season. 7-day PHI.
- Leafhoppers on head lettuce: 3.8-6.1 fl. oz. per acre.
- Flea beetles: 5.1-6.1 fl. oz. per acre. Do not exceed 30.72 fl. oz. (0.24 lb. a.i. of imidacloprid and 0.24 lb. a.i. of bifenthrin) per acre per season. 7-day PHI.
- Flea beetles on spinach only: 5.1-6.14 fl. oz. per acre. Do not exceed 30.72 fl. oz. (0.24 lb. a.i. of imidacloprid and 0.24 lb. a.i. of bifenthrin) per acre per season. 40-day PHI.

RUP.

Capture® (LFR) at the following rates:

- Soil applications: See label for application methods.
- Flea beetle larvae on cilantro and coriander only: 3.4-6.8 fl. oz. per acre. 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). RUP.

Dimethoate® (4E) at 0.5 pt. per acre. Leafhoppers only. Not for parsley, spinach, celery, or head lettuce. 14-day PHI for endive, swiss chard, and leaf lettuce.

Hero® at 4-10.3 oz. per acre. Head lettuce only. Do not exceed 46.35 oz. (0.45 lb. a.i.) per acre per season. Observe resistance management restrictions for some of the target pests. 7-day PHI. RUP.

Hero EW® at 4.5-11.2 oz. per acre. Head lettuce only. Do not exceed 50.5 oz. (0.45 lb. a.i.) per acre per season. Observe resistance management restrictions for some of the target pests. 7-day PHI. RUP.

Mustang Maxx® (0.8EC) at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 5-day PHI. RUP.

Neemix 4.5® at 7-16 fl. oz. per acre. Leafhopper nymphs only. 0-day PHI.

Platinum® (2SC) at 5-11 fl. oz. per acre. 30-day PHI.

Orthene® (97S) at 8-16 oz. per acre. Aster leafhopper only on head lettuce (crispyhead type) only. Do not exceed 2 1/8 lbs. a.i. per acre per season. 21-day PHI.

Permethrin® (3.2EC) at 2-8 fl. oz. per acre. Leafhoppers only. Spinach: Do not exceed 24 fl. oz. per acre per season. Lettuce: Do not exceed 32 fl. oz. per acre per season. 1-day PHI. RUP.

Platinum® (2SC) at 5-11 fl. oz. per acre in soil applications. See label for application methods. Do not exceed 11 fl. oz. (0.172 lb. a.i. of thiamethoxam) per acre per season. 30-day PHI.

Sevin XLR PLUS® (4F) at 0.5-2 qts. per acre. Do not exceed 6 qts. per acre per season. 14-day PHI.

Sivanto® (200SL) at 7-10.5 fl. oz. per acre. Leafhoppers only. Do not exceed 28 fl. oz. per acre per season. 1-day PHI.

Torac® (1.29EC) at 14-21 fl. oz. per acre. Do not exceed 2 applications per season. 1-day PHI.

Venom® (70SG) for leafhoppers only at the following rates:

- Foliar applications: 1-3 fl. oz. per acre. 7-day PHI.
- Soil applications: 5-6 fl. oz. per acre. 21-day PHI

Warrior II® (2.08CS) at 1.28-1.92 fl. oz. per acre. Lettuce only. Do not exceed 19.2 fl. oz. per acre per season. 1-day PHI. 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.

Recommended Products

Deadline M-Ps® (4B) at 25 lbs. per acre. Do not exceed 3 applications of product per crop cycle. 0-day PHI.

Durham® (metaldehyde 3.5 G). Apply up to 40 pounds per acre. Do not exceed 86 lbs. (3 lbs. a.i.) per acre per crop cycle. Do not allow bait granules to come in contact with plants. Never apply to dry soil.

Sluggo Plus (1B) at 22-44 lbs. per acre, or at 0.5-1 lb. per 1,000 square ft. Lettuce and spinach only. 0-day PHI.
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.

Recommended Products

Ambush® (25W) at 6.4-12.8 oz. per acre. Leafminers only. Spinach: Do not exceed 1 lb. a.i. per acre per season. All others: Do not exceed 2 lbs. per acre per season. 1-day PHI. RUP.

Athena® at the following rates:
- Head lettuce: 13.5-17 fl. oz. per acre. Do not exceed 50 fl. oz. per acre per season after transplanting. 7-day PHI.
- Spinach: 13.5-17 fl. oz. per acre. Do not exceed 62 fl. oz. per acre per season after transplanting. 40-day PHI. RUP.

Baythroid XL® (1EC) at 2.4-3.2 fl. oz. per acre. 0-day PHI. Do not exceed 12.8 fl. oz. (0.1 lb a.i.) per acre per season. RUP.

Beleaf® (50SG) at 2-2.8 oz per acre. Do not exceed 8.4 oz. (0.267 lb. a.i.) per acre per season. 0-day PHI.

Brigade® (2EC) at 5.12-6.4 fl. oz. per acre. Head lettuce and spinach only. Head lettuce: Do not exceed 0.5 lb. a.i. per acre per season. 7-day PHI. Spinach: Do not exceed 0.4 lb. a.i. per acre per season. 40-day PHI for spinach. RUP.

Brigadier® (50SG) at the following rates:
- Head lettuce: 3.8-6.1 fl. oz. per acre. 7-day PHI.
- Spinach: 3.8-6.14 fl. oz. per acre. 40-day PHI.

Do not exceed 30.72 fl. oz. (0.24 lb. a.i. of imidacloprid and 0.24 lb. a.i. of bifenthrin) per acre per season. RUP.

Hero® at 10.3 oz. per acre. Head lettuce only. Do not exceed 46.35 oz. (0.45 lb. a.i.) per acre per season. 7-day PHI. RUP.

Hero EW® at 11.2 oz. per acre. Head lettuce only. Do not exceed 50.5 oz. (0.45 lb. a.i.) per acre per season. 7-day PHI. RUP.

Mustang Maxx® (0.8EC) at 3.2-4 fl. oz. per acre. Do not exceed 24 fl. oz. (0.15 lb. a.i.) per acre per season. 1-day PHI. RUP.

Sevin XLR PLUS® (4F) at 1-2 qts. per acre. Do not exceed 6 qts. per acre per season. 14-day PHI.
Most herbs will 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, since 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.

**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 average-fertility soils, apply 120 to 150 pounds of N per acre, 120 to 180 pounds of P₂O₅ per acre, and 120 to 180 pounds of K₂O 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. 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.

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 per 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. See the Leafy Vegetables chapter (page 146) for specific herbicides labeled for herbs.

Practicing good sanitation and paying attention to seed sources will help to lessen diseases. More information about pest control in herbs, see the Leafy Vegetables chapter (page 146).

**Marketing**

Fresh herbs certainly make excellent cash crops. However, growers should be very 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 appear below.

**Basil**

Basil, French basil, or sweet basil (*Ocimum basilicum*) is a popular, tender, annual herb. It is 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 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.

**Chives**

Chives, *Allium schoenoprasum*, is a perennial that is 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 omelettes.

Chive seeds require darkness, constant moisture, and a temperature of 60°F to 70°F for best results. Sow them ½ inch deep in pots or flats. Germination will occur 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, *Anthem 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 will grow 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. Xpipita*), 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. The pests that could bother mint include: spider mites, loopers, mint flea beetles, mint root borers, cutworms, root weevils, and aphids. For details, see Mint, page 173.

**Oregano**

Oregano, *Origanum vulgare* subsp. Hirtum also referred to as *O. Heracleoticum* and *O. Hirtum*, is native to the Mediterranean region. It is 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 since 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 will 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 P₂O₅ per acre, and 100 to 120 pounds of K₂O 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% 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 piny, 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.

*Herbs*

Basil is a potentially high-value crop that may be grown successfully in a hydroponic setting.
# Legumes — Snap Bean, Dry Bean, Lima Bean

## Snap Bean Varieties

<table>
<thead>
<tr>
<th>Snap Bean Varieties</th>
<th>Use</th>
<th>Pod Color</th>
<th>Seed Color</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bush Snap Bean Varieties—Green Pod</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benchmark</td>
<td>market</td>
<td>medium-dark green</td>
<td>white</td>
<td>excellent quality</td>
</tr>
<tr>
<td>Bronco</td>
<td>market</td>
<td>dark green</td>
<td>white</td>
<td>excellent quality, mechanical harvest</td>
</tr>
<tr>
<td>Daytona</td>
<td>market</td>
<td>medium green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>Envy</td>
<td>processing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evergreen</td>
<td>processing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flo</td>
<td>processing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hialeah</td>
<td>market</td>
<td>green</td>
<td>white</td>
<td>excellent quality</td>
</tr>
<tr>
<td>Hystyle</td>
<td>market, processing</td>
<td>dark green</td>
<td>white</td>
<td>mechanical harvest</td>
</tr>
<tr>
<td>Labrador</td>
<td>market, processing</td>
<td>dark green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>Opus</td>
<td>market</td>
<td>medium-light green</td>
<td>white</td>
<td>rust tolerant</td>
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<tr>
<td>Rushmore</td>
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<td>medium green</td>
<td>brown</td>
<td>early</td>
</tr>
<tr>
<td>Strike</td>
<td>market</td>
<td>medium-light green</td>
<td>white</td>
<td>mechanical harvest</td>
</tr>
<tr>
<td>Tema</td>
<td>market</td>
<td>medium-dark green</td>
<td>brown</td>
<td></td>
</tr>
<tr>
<td>Venture</td>
<td>market, processing</td>
<td>dark green</td>
<td>white</td>
<td>early</td>
</tr>
<tr>
<td><strong>Yellow Pod</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eureka</td>
<td>market</td>
<td>yellow</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>Gold Mine</td>
<td>market</td>
<td>yellow</td>
<td>white</td>
<td>susceptible to brown spot</td>
</tr>
<tr>
<td>Gold Rush</td>
<td>market, processing</td>
<td>yellow</td>
<td>white</td>
<td>susceptible to brown spot</td>
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<tr>
<td>Kinghorn Wax</td>
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<td>excellent quality</td>
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<td>Klondyke</td>
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<td>mechanical harvest</td>
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<tr>
<td>Nugget</td>
<td>market, processing</td>
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<td>white</td>
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</table>

## Lima Bean Varieties

<table>
<thead>
<tr>
<th>Lima Bean Varieties</th>
<th>Use</th>
<th>Seed Color</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bridgeton</strong></td>
<td>processing</td>
<td>greenish</td>
<td>Bush, late, medium size</td>
</tr>
<tr>
<td><strong>Fordhook 242</strong></td>
<td>market &amp; home</td>
<td>white</td>
<td>Bush, midseason, medium size, variable yield</td>
</tr>
<tr>
<td><strong>Henderson Bush</strong></td>
<td>market &amp; home</td>
<td>white</td>
<td>Bush, very early, small seed, high yield</td>
</tr>
<tr>
<td><strong>King of the Garden</strong></td>
<td>home garden</td>
<td>greenish-white</td>
<td>Pole, midseason to late, large seed</td>
</tr>
</tbody>
</table>
Legumes — Pea and 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.

### Pea Varieties

<table>
<thead>
<tr>
<th>Variety</th>
<th>Season</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>English Shell Peas</strong></td>
<td>Spring</td>
<td>Early</td>
</tr>
<tr>
<td>Knight</td>
<td>Early</td>
<td>Short vines</td>
</tr>
<tr>
<td>Bolero</td>
<td>Mid</td>
<td></td>
</tr>
<tr>
<td>Green Arrow</td>
<td>Mid-late</td>
<td>Long holding in field</td>
</tr>
<tr>
<td>Lincoln</td>
<td>Mid-late</td>
<td>Very sweet, home garden variety</td>
</tr>
<tr>
<td><strong>Snap peas (edible-podded)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar Bon</td>
<td>Early</td>
<td>Short vines</td>
</tr>
<tr>
<td>Sugar Ann</td>
<td>Early</td>
<td>Short vines</td>
</tr>
<tr>
<td>Cascadia</td>
<td>Main</td>
<td></td>
</tr>
<tr>
<td>Supersnappy</td>
<td>Main</td>
<td>Large pods</td>
</tr>
<tr>
<td><strong>Snow peas (edible-podded)</strong></td>
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<td></td>
</tr>
<tr>
<td>Oregon Giant</td>
<td>Mid-late</td>
<td>Large pods</td>
</tr>
<tr>
<td>Snowflake</td>
<td>Late</td>
<td>Dark green</td>
</tr>
<tr>
<td>Super Sugar Pod</td>
<td>Late</td>
<td>Long vines</td>
</tr>
<tr>
<td><strong>Southern Peas or Cowpeas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brown Crowder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mississippi Silver (crowder)</td>
<td></td>
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<tr>
<td>Purple Crowder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas Cream Cowpea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zipper Cream Cowpea</td>
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</tr>
</tbody>
</table>

### 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. **P₂O₅**: 0 to 100 pounds per acre. **K₂O**: 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 P₂O₅ 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.

### Disease Control

**Rust, Anthracnose (dry beans and cowpeas)**

Follow 2-3 year rotation schedules. Rust resistant varieties are available. Use seed free of the pathogen.

### Recommended Products

- **Aproach®** at 6-12 fl. oz. per acre. 14-day PHI.
- **Aprovia Top®** at 10.5-11 fl. oz. per acre. A spreader-stick- er is recommended. 14-day PHI.
- **Bravo®, Echo®,** and **Equus®** are labeled for use at various rates. 14-day PHI.
- **Headline®, or Headline SC®** at 6-9 oz. per acre. 21-day PHI.
- **Fontelis®** at 14-20 fl. oz. per acre. 21-day PHI.
- **Priaxor®** at 4-8 fl. oz. per acre. 21-day PHI.
- **Proline 480SC®** at 5.7 fl. oz. per acre. **Rust only.** 7-day PHI.
- **Quadris®** at the following rates:
  - **Anthracnose**: 6.0-15.4 fl. oz. per acre.
  - **Rust**: 6.0 fl. oz. per acre.
  - 14-day PHI.

- **Quadris Opti®** at 1.6-2.4 pts. per acre. 14-day PHI.
Quilt Xcel® at 10.5-14 fl. oz. per acre. 14-day PHI.
Tilt® at 4 fl. oz. per acre. 7-day PHI.
Topsin M WSB®. See labels for rates. Anthracnose only. 28-day PHI.
Vertisan® at 14-20 fl. oz. per acre. 21-day PHI.

**Rust, Anthracnose (snap beans and other succulent beans — check labels)**
Follow 2-3 year rotation schedules. Rust resistant varieties are available. Use seed free of the pathogen.

**Recommended Products**
- **Bravo®, Echo®, and Equus®** are labeled for use at various rates. 7-day PHI.
- **Fontelis®** at 14-30 fl. oz. per acre. 0-day PHI.
- **Headline®** at 6-9 oz. per acre. 7-day PHI.
- **Priaxor®** at 4-8 fl. oz. per acre. 7-day PHI.
- **Quadris®** at the following rates:
  - Anthracnose: 6.2-15.4 fl. oz. per acre.
  - Rust: 6.2 fl. oz. per acre.
    0-day PHI.
- **Quilt®** at 14 fl. oz. per acre. 7-day PHI.
- **Quilt Xcel®** at 10.5-14 fl. oz. per acre. 7-day PHI.
- **Rally 40WSP®** at 4-5 oz. per acre. *Rust only*. 0-day PHI.
- **Tilt®** at 4 fl. oz. per acre. 7-day PHI.
- **Topsin 70W®, or Topsin 4.5L®.** See labels for rates. Anthracnose only. 14-day PHI.

**Bacterial Blights**
Plant western-grown, certified disease-free seed. Practice a 2-year crop rotation and plow under bean stubble in the fall. Apply a fixed copper product such as Kocide®, Champ®, or Cuprofix® at 5-7 day intervals to reduce spread (0-day PHI) if weather conditions favor disease spread.

**Fusarium Wilt**
Use resistant cultivars. Rotate away from legumes for several years to avoid build up of the Fusarium fungus.

**Seed Rot and Damping-off**
Use pathogen-free seed. Purchase seed commercially treated with a product such as Apron Maxx®, Captain®, or Thiram®. If Pythium is a significant problem, apply Ridomil Gold SL® at 0.5-1.0 pt. per acre at planting.

**White Mold and Gray Mold**
Avoid fields with a history of white mold or with poor drainage.

**Recommended Products**
- **Aproach®** at 8-12 fl. oz. per acre. *White mold suppression only*. 14-day PHI.
- **Bravo®, Echo®, and Equus®** are labeled for use at various rates. *Gray mold on snap beans only*. 7-day PHI.
- **Cannonball WG®** at 7 oz. per acre. Do not exceed 28 oz. per acre per year. 7-day PHI.
- **Contans WG®** at 1-4 lbs. per acre for white mold on snap beans. Contans® is applied with conventional spray equipment directly to the soil surface at planting.
- **Endura 70WG®** at 8-11 oz. per acre. 7-day PHI for snap bean. 21-day PHI for dry beans.
- **Fontelis®** at the following rates:
  - Gray mold: 14-30 fl. oz. per acre.
  - White mold: 16-30 fl. oz. per acre.
    0-day PHI for succulent beans. 21-day PHI for dry beans.
- **Omega 500F®** at 0.5-0.85 pt. per acre. Do not exceed 1.75 pts. per acre per season. 14-day PHI for edible podded and succulent beans. 30-day PHI for dry and lima beans.
- **Rovral 75WG®** at 1.5-2 pts. per acre. 0-day PHI.
- **Proline 480 SC®** at 5.7 fl. oz. per acre. *White mold on dry beans only*. 7-day PHI.
- **Switch 62.5WG®** at 11-14 oz. per acre. 7-day PHI.
- **Topsin M WSB®.** See labels for rates. 14-day PHI for snap beans. 28-day PHI for dry and lima beans.

**Soybean Cyst Nematode (SCN)**
Rotate at least 2-3 years with corn, small grains, alfalfa, or other non-host crops. Do not include soybeans in the rotation.

**Bean Yellow Mosaic Virus (BYMV)**
No adequate control measure is known. Eliminating overwintering host plants, such as wild sweet clover may reduce infection. Some tolerant varieties are available.

**Weed Control**
For specific weeds controlled by each herbicide, check Table 25 on page 66.

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

**Broadleaves and Grasses**

**Recommended Products**

*Glyphosate* products at 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 seeding 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. 14-day PHI.

*Gramoxone Inteon 2L* at 2-4 pts. per acre. *Lima bean, snap bean, and pea only.* 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.*

*Spartan Advance*. See details below for Preemergence Broadleaves.

**Burndown or Directed/Shielded Application Broadleaves**

**Application Broadleaves**

*Aim EC* at 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.

*Optill*. See detail below for Preemergence Broadleaves.

*Sharpen* at 1-2 oz. burndown before the crop emerges. *Chickpeas and dry peas only.* Surface apply early pre-plant through pre-emergence. Add MSO at 1 pt. per acre when used as a pre-plant burndown. Do not apply group 14, E herbicides within 30 days of planting. Do not apply when legumes reach cracking stage.

*Spartan Charge*. See details below for Preemergence Broadleaves.

**Preemergence Broadleaves and Grasses**

**Recommended Products**

*Command 3ME* at the following rates:

- *Peas and cowpeas*: 1.3 pts. per acre.
- *Succulent lima beans and snap beans*: 0.4-0.67 pt. per acre.

Broadcast before planting, or after planting before crop emerges. Not effective on muck soil. 45-day PHI for succulent and snap beans.

*Dual Magnum*, or *Dual II Magnum* at 1-2 pts. per acre. Use lower rates on coarse soils. *Peas:* apply prior to planting. Do not incorporate in English peas. *Beans:* apply and incorporate before planting, or apply after seeding but before crop emerges. Can be tank-mixed preplant incorporated with Eptam* or trifluralin. Do not use on muck soils.

*Eptam 7E* at 3.5 pts. per acre, or *Eptam 20G* at 15 lbs. per acre. *Dry beans and snap beans only.* Apply before planting and incorporate immediately, or apply as a directed spray at last cultivation. Check label for sensitive varieties. *Snap beans and navy beans on coarse soils:* Do not exceed 3.5 pts. per acre. *All other labeled crops:* Do not exceed 9.75 pts. per acre.

**MicroTech** at the following rates:

- *Lima beans*: 2.5-3 qts. per acre.
- *Red kidney types of dry bean in Illinois only*: 2.5-3 qts. per acre.

Apply before planting and incorporate. *RUP.*

*Outlook* at 10-21 fl. oz. per acre. *Dry beans only.* Use lower rate on coarse soils that 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. 70-day PHI.

*Pendimethalin* for most legumes (black, chickpeas, garbanzo, great northern, red kidney, lentils, navy, pea, snap bean, etc.) products at the following rates:

- *3.3EC formulations*: 1.2-3.6 pts. per acre.
- *Prowl H2O*: 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.

*Sonalan* at 1.5-4.5 pts. per acre. *Dry beans only.* Not for *muck soils.* Apply and incorporate before planting. Use higher rates to suppress eastern black nightshade.

*Trifluralin* products at 0.5-0.75 lb. a.i. per acre. Use 4EC formulations at 1-1.5 pts. per acre. Use lowest rate on coarse soils. Apply and incorporate before planting. Not effective on soils with high organic matter.

**Preemergence Broadleaves**

**Recommended Products**

*Optill* at 1.5 oz per acre. *Field and English peas and chickpeas only.* English peas (green shelled, snap, or snow peas) are labeled only in Illinois, Iowa, Minnesota, and Wisconsin. Apply preplant, preplant-incorporated or pre-emergence (up to 3 days after planting before cracking). Plant English and sugar snap peas at least 1/2-inch deep to avoid injury. Apply before cracking. A sequential application of Sharpen® may be made with a minimum of 30 days between applications. Do not apply north of Highway 210 in Minnesota. Do not use on any *Phaseolus* bean species. Do not apply group 14, E herbicides within 30 days of planting.

*Sharpen* at the following rates:

- *Peas in Illinois, Iowa, Michigan, Minnesota, and Wisconsin*: 0.75 fl. oz. per acre.
- *Lentils in Minnesota, or chickpeas in all states*: 0.75-2.0 fl. oz. per acre.

Apply 0.75 fl oz. per acre rate preplant incorporated or pre-emergence (in peas up to 3 days after planting before cracking) to suppress 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, E herbicides within 30 days of planting.

**Spartan 4F** at 2.25-8 oz. per acre. **Dry peas and chickpeas only.** Labeled for Michigan, Minnesota, and Wisconsin. Fall- or spring-apply early-preplant, preplant-incorporated, or pre-emergence. Rate depends on soil texture, organic matter, and pH. Do not use on soils with less than 1% organic matter or apply after crop emerges.

**Spartan Advance** at 16-57 oz. per acre **Dry peas and chickpeas only.** Labeled for Michigan, Minnesota, and Wisconsin. Fall- or spring-apply early-preplant, preplant-incorporated, or pre-emergence. 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.

**Spartan Charge** at the following rates:

- **Dry peas and chickpeas:** 3-10.2 oz. per acre. Apply preplant-burndown, early-preplant, or pre-emergence. Do not use on coarse soils with less than 1% soil organic matter.
- **Dry beans in Minnesota only:** 3.75-5.75 oz. per acre. Apply early-preplant or pre-emergence. Do not use on soils with less than 1.5% organic matter.

**Permit** on **dry beans only** at the following rates:

- **Preemergence and postemergence broadcast or postemergence directed sprays:** 0.5-0.66 oz. per acre.
- **Row middle applications:** 0.5-1 oz. per acre.

Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Apply after planting but prior to soil cracking. Row-middle applications with no crop contact may be used after crop emergence. Do not exceed 1 oz. per acre per crop cycle, or 2 oz. per acre per 12-month period.

**Pursuit** products at the following rates:

- **Cowpeas:** **Pursuit 2L** at 4 fl. oz. per acre, or **Pursuit DG** at 1.44 oz. per acre.
- **Dry beans, lima beans, and peas:** **Pursuit 2L** at 3 fl. oz. per acre, or **Pursuit DG** at 1.08 oz. per acre.
- **Snap beans in Illinois and Minnesota:** **Pursuit 2L** at 1.5 fl. oz. per acre.
- **All labeled crops in Minnesota north of Highway 210:** **Pursuit 2L** at 2 fl. oz. per acre only, or **Pursuit DG** at 0.72 oz. per acre only. Use 8 oz. of NIS per 25 gals. of spray solution if emerged weeds are present.
- **Snap beans in Illinois and Minnesota:** Apply and incorporate within 1 week of planting, or apply within 1 day after planting. Apply before July 31.

All other labeled crops: Apply and incorporate within 1 week of planting, or apply within 3 days after planting before crop emerges, or apply after beans have 1 fully expanded trifoliate leaf. Do not apply Pursuit® to fields treated with trifluralin or injury may occur. If N fertilizer is added to a postemergence application, Basagran® must be added to minimize crop injury. Refer to Basagran® label for rates. 30-day PHI for succulent peas and snap beans. 60-day PHI for all others.

**Reflex®** on **dry beans and snap beans only** at the following rates:

- **Extreme southeast Missouri:** 1.5 pts. per acre per year (Region 5).
- **Indiana and Illinois south of I-70:** 1.5 pts. per acre in alternate years (Region 4).
- **Indiana and Illinois north of I-70; and the rest of Missouri:** 1.25 pts. per acre in alternate years (Region 3).
- **Kansas east of Highway 281 and Minnesota south of I-94:** 1 pt. per acre in alternate years (Region 4).
- **Minnesota south of Highway 2 and north of I-94:** 0.75 pt. per acre in alternate years (Region 5).

**Not for lima beans.** Reflex® is labeled in all states participating in this publication except in Kansas west of Highway 281 and in Minnesota north of Highway 2. Preemergence applications are labeled for all stated including Kansas east of Highway 281 and in Minnesota south of Interstate 94. Postemergence applications include Minnesota south of Highway 2 and Kansas east of Highway 281. The spectrum of weeds controlled varies by application method. For postemergence applications, apply 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. 30-day PHI for snap beans. 45-day PHI for dry beans.

**Sandea®** at the following rates:

- **Dry beans with preemergence and postemergence broadcast or postemergence directed sprays:** 0.5-0.67 oz. per acre.
- **Dry beans with row middle applications:** 0.5-1 oz. per acre.
- **Snap beans and lima beans preemergence or middle row applications:** 0.5-1 oz. per acre.
- **Snap beans and lima beans postemergence:** 0.5-0.67 oz. per acre.
- **Succulent peas preemergence:** 0.5 oz. per acre. Vigna species only: black-eyed pea, cowpea, southern pea.
- **Succulent peas postemergence:** 0.5-1 oz. per acre. Vigna species only: black-eyed pea, cowpea, southern pea. Directed sprays recommended.

Use 0.5-1 pt. of NIS per 25 gals. of spray solution if emerged weeds are present. Use lower rates on coarse soils with low organic matter. Apply after planting but prior to cracking. For postemergence
applications, apply to dry beans after plants have 1-3 trifoliate leaves but before flowering; apply to snap beans or lima beans after the crop has 2-4 trifoliate leaves but before flowering (directed spray may limit injury); and to Vigna spp. as 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 0.67 oz. per acre per crop-cycle for dry beans, or 1 oz. per acre per crop-cycle for snap beans and succulent pea (Vigna spp. only). Do not exceed 2 oz. per acre per 12-month period. 30-day PHI.

**Postemergence Broadleaves and Grasses**

**Recommended Products**

*Glyphosate* products. See details above for Burndown or Directed/Shielded Application Broadleaves and Grasses.

**Raptor** at the following rates:

Dry beans (see label for specific types) and dry peas: 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. Do not exceed 1 application of Raptor® per year.

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. Do not exceed 1 application per year.

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. Do not exceed 1 application per year.

Succulent (English) peas (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. Do not exceed 1 application per year.

**Postemergence Broadleaves**

**Recommended Products**

Aim EC®. See details above for Burndown or Directed/Shielded Application Broadleaves.

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. 30-day PHI.

**Postemergence Grasses**

**Recommended Products**

Assure II® at 5-12 fl. oz. per acre. Dry beans, snap beans, and peas only. Use 1 qt. of COC per acre. Apply to actively growing grass. Do not exceed 14 fl. oz. per acre. 30-day PHI for succulent peas and dry beans. 15-day PHI for snap beans. 60-day PHI for dry peas.

Clethodim products at the following rates:

Select Max® at 9-16 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

2EC formulations of clethodim products at 6-8 fl. oz. per acre. Use 2EC formulations with 1 qt. of COC per 25 gals. of spray solution (1% v/v). Do not exceed 32 fl. oz. of 2EC formulations per acre per season.

Use low rates for annual grasses, and use high rates for perennial grasses. Apply to actively growing grass. 21-day PHI for crops harvested before they dry down. 30-day PHI for dry beans, dry lima beans, and dry peas.

Fusilade DX 2E® at 8-12 fl. oz. per acre. Dry beans only. 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. 60-day PHI.

Poast 1.5E® at 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. 15-day PHI for succulent beans and peas. 30-day PHI for dry beans and dry peas.

Targa® at 5-12 fl. oz. per acre. Dry beans, snap beans, and peas only. Use 1 qt. of COC per acre. Apply to actively growing grass. Do not exceed 14 fl. oz. per acre. 30-day PHI for succulent peas and dry beans. 15-day PHI for snap beans. 60-day PHI for dry peas.
### Herbicides for Legumes

<table>
<thead>
<tr>
<th>Products (REI/PHI)</th>
<th>Common Name</th>
<th>Timing and Application Location Relative to Crop</th>
<th>Incorporated</th>
<th>Timing Relative to Weeds</th>
<th>Weed Groups Controlled</th>
<th>Crops[^3]</th>
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<tr>
<td>Aim EC* (12h/-)</td>
<td>carfentrazone</td>
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<td>Pursuit* (12h/30d)</td>
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<td>X  X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Raptor* (4h/0-30d)</td>
<td>fomesafen</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reflex* (12h/30d to 45d)</td>
<td>fomesafen</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Roundup*, others (12h/14d)</td>
<td>glyphosate</td>
<td>X  X  X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sandea* (12h/30d)</td>
<td>halosulfuron</td>
<td>X  X  X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Select Max*, others (12h/21-30d)</td>
<td>clethodim</td>
<td>X  X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sharpen* (12h/0d)</td>
<td>saflufenacil</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sonalan*</td>
<td>ethalfluralin</td>
<td>X</td>
<td>Yes</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Spartan 4F* (12h/-)</td>
<td>sulfentrazone</td>
<td>X  X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Spartan Advance* (12h/90d)</td>
<td>sulfentrazone + glyphosate</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Spartan Charge* (12h/-)</td>
<td>sulfentrazone + carfentrazone</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Targa* (12h/15d to 60 d)</td>
<td>quizalofop</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Treflan*, others (12h/-)</td>
<td>trifluralin</td>
<td>X</td>
<td>Yes</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

[^1]: For effectiveness against specific weeds, see Table 25 on page 66, 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.

[^3]: X=permitted on this crop in at least one state.
Insect Control

**Aphids and Leafhoppers**

**Potato Leafhopper Thresholds**

- **Seedlings**: 0.5 per sweep, or 2 per row foot
- **3rd Trifoliate**: 1 per sweep, or 5 per row foot
- **Bud Stage**: 5 per row foot

**Recommended Products**

- **Admire PRO® (4.6F)** at the following rates:
  - **Soil applications**: 7-10.5 fl. oz. per acre. Do not exceed 1 application per season. 21-day PHI.  
  - **Foliar applications**: 1.2 fl. oz. per acre. Do not exceed 3 applications per season. 7-day PHI.

- **Asana XL® (0.66EC)** at 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 vines. 3-day PHI for succulent legumes. 21-day PHI for dry legumes. RUP.

- **Assail 30SG®** at 2.5-5.3 oz. per acre. Do not exceed 3 applications per season. 7-day PHI.

- **Baythroid XL® (1EC)** at 2.4-3.2 fl. oz. per acre. **Leafhoppers on dry beans and peas only.** Dry beans: Do not exceed 6.4 fl. oz. per acre per season. 7-day PHI. **Southern peas**: Do not exceed 10.5 fl. oz. per acre per season. 3-day PHI. Allow 14 days between applications for all labeled crops. RUP.

- **Brigade® (2EC)** at 1.6-6.4 fl. oz. per acre (do not exceed 12.8 fl. oz. per acre per season), or **Brigade® (WSB)** at 4-16 oz. per acre (do not exceed 32 oz. per acre per season). 3-day PHI for succulent legumes. 14-day PHI for dry legumes. RUP.

- **Cruiser 5FS® or Cruiser Maxx®**. Rates vary by seeding rate and spacing. See labels. Cruiser® provides against early season injury by pests.

- **Dimethoate 4E® or Dimethoate 400®** at 0.5-1 pt. per acre. **Not for cowpeas.** Do not feed treated plants to livestock. Do not apply during bloom. 0-day PHI for Dimethoate 400® (mechanical harvest only). 2-day PHI for Dimethoate 4E®.

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**M-Pede®** at 1-2% by volume. **Aphids only.** Must contact aphids to be effective. 0-day PHI.

**Mustang Maxx® (0.8EC)** at the following rates:

- **Aphids**: 3.2-4.0 oz. per acre.
- **Leafhoppers**: 2.72-4.0 fl. oz. per acre.

Do not exceed 0.15 lb. a.i. per acre per season. 1-day PHI for succulent beans. 21-day PHI for dry beans. RUP.

- **Movento® (2SC)** at 4-5 fl. oz. per acre. **Aphids only.** Do not exceed 10 fl. oz. per acre per season. 1-day PHI for succulent beans. 7-day PHI for dry beans.

**Orthene® (97S)** at 0.5-1 lb. per acre. **Do not feed treated vines to livestock. Not for use on snap beans.** Do not exceed 2 1/8 lbs. per acre per season. 14-day PHI for dry beans. 1-day PHI for lima beans.

**Sevin XLR PLUS® (4F)** at 0.5-1 qt. per acre. **Not for aphids.** Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 14-day PHI for forage. 21-day PHI for dry legumes.

**Sivanto® (200SL)** at 7-10.5 fl. oz. per acre. 7-day PHI.

**Thimet 20G®** at 4.5-7.0 oz. per 1,000 linear ft. of row at any spacing. Drill granules to the side of the seed. Do not place granules in direct contact with seed. **Do not feed bean foliage to livestock.** 60-day PHI. RUP.

**Warrior II® (2.08CS)** at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. RUP.

**Caterpillars (Alfalfa Caterpillars, Armyworms, Corn Earworms, Cutworms, European Corn Borers, and Loopers)**

**Recommended Products**

- **Asana XL® (0.66EC)** at 5.8-9.6 fl. oz. per acre. Do not exceed 38.4 fl. oz. per acre per season. **Do not feed treated vines to livestock.** 3-day PHI for succulent legumes. 21-day PHI for dry legumes. RUP.
**Legumes - Insect Control**

**Baythroid XL® (1EC)** at 2.4-3.2 fl. oz. per acre. *Dry beans and peas only.* *Dry beans:* Do not exceed 6.4 fl. oz. per acre per season. 7-day PHI. *Southern peas:* Do not exceed 10.5 fl. oz. per acre per season. 3-day PHI. Allow 14 days between applications for all labeled crops. *RUP.*

**Blackhawk®** at 1.7-3.3 oz. per acre. Do not exceed 6 applications per season. 3-day PHI for succulent legumes. 28-day PHI for dry legumes.

**Brigade® (2EC)** at 1.6-6.4 fl. oz. per acre (do not exceed 12.8 fl. oz. per acre per season), or **Brigade® (WSB)** at 4-16 oz. per acre (do not exceed 32 oz. per acre per season). 3-day PHI for succulent legumes. 14-day PHI for dry legumes. *RUP.*

**Coragen® (1.67SC)** at 3.5-5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. 1-day PHI.

**Entrust® (2SC)** at 3-6 fl. oz. per acre. *Succulent beans and peas:* Do not exceed 29 fl. oz. per acre per season. 3-day PHI. *Dry beans and peas:* Do not exceed 12 fl. oz. per acre per season. 28-day PHI.

**Intrepid 2F®** at 4-16 fl. oz. per acre. 7-day PHI.

**Lannate LV® (2.4WSL)** at 1.5-3 pts. per acre. Do not exceed 15 pts. per acre per crop. 1-day PHI for peas. 5-day PHI for forage. 14-day PHI for hay. *RUP.*

**Mustang Maxx® (0.8EC)** at 2.72-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI for succulent legumes. 21-day PHI for dairy. *RUP.*

**Sevin XLR PLUS® (4F)** at 1.5 qts. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 21-day PHI for dry legumes.

**Warrior II® (2.08EC)** at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP.*

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**Cowpea Curculios, Pea Weevils (cowpeas)**

**Recommended Products**

**Asana XL® (0.66EC)** at 4.8-9.6 fl. oz. per acre. *Dry legumes only.* Do not exceed 38.4 fl. oz. per acre per season. Do not feed treated vines to livestock. 21-day PHI. *RUP.*

**Baythroid XL® (1EC)** at the following rates:

*Cowpea curculios:* 1.6-2.4 fl. oz. per acre.

*Pea weevils:* 2.4-3.2 fl. oz. per acre.

*Dry beans:* Do not exceed 6.4 fl. oz. per acre per season. 7-day PHI.

*Southern peas:* Do not exceed 10.5 fl. oz. per acre per season. 3-day PHI.

*Dry beans and peas only.* Allow 14 days between applications. *RUP.*

**Brigade® (2EC)** at 2.1-6.4 fl. oz. per acre (do not exceed 12.8 fl. oz. per acre per season), or **Brigade® (WSB)** at 5.3-16 oz. per acre (do not exceed 32 oz. per acre per season). 14-day PHI. *RUP.*

**Mustang Maxx® (0.8EC)** at 2.72-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI for succulent legumes. 21-day PHI for dry legumes.

**Sevin XLR PLUS® (4F)** at 1.5 qts. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 21-day PHI for dry legumes.

**Warrior II® (2.08EC)** at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP.*

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**Mexican Bean Beetles, Bean Leaf Beetles**

**Bean Leaf Beetle Threshold**

1 beetle per foot of row

**Mexican Bean Beetle Threshold**

0.5 beetle per plant

**Recommended Products**

**Asana XL® (0.66EC)** at 2.9-5.8 fl. oz. per acre. *Mexican bean beetle only.* *Not for bean leaf beetles.* Do not exceed 38.4 fl. oz. per acre per season. Do not feed or graze livestock on treated vines. 3-day PHI for succulent legumes. 21-day PHI for dry legumes. *RUP.*
Baythroid XL® (1EC) at 2.4-3.2 fl. oz. per acre. Dry beans and peas only. Dry beans: Do not exceed 6.4 fl. oz. per acre per season. Southern peas: Do not exceed 10.5 fl. oz. per acre per season. 7-day PHI. Allow 14 days between applications for all labeled crops. RUP.

Brigade® (2EC) at 1.6-6.4 fl. oz. per acre (do not exceed 12.8 fl. oz. per acre per season), or Brigade® (WSB) at 4-16 oz. per acre (do not exceed 32 oz. per acre per season). Not for Mexican bean beetles. 3-day PHI for succulent legumes. 14-day PHI for dry legumes. RUP.

Cruiser 5FS® or Cruiser Maxx®. Rates vary by seeding rate and spacing. See labels. Cruiser® provides against early season injury by pests.

Dimethoate 4E® or Dimethoate 400® at 0.5-1 pt. per acre. Not for cowpeas. Do not feed to livestock. Do not apply during bloom. 0-day PHI for Dimethoate 400® (mechanical harvest only). 2-day PHI for Dimethoate 4E®.

Lannate LV® (2.4WSL) at 0.75-3 pts. per acre. Not for bean leaf beetles. Do not feed hay to livestock for 7 days. 1-day PHI for succulent peas and succulent beans at 0.75-1.5 pts. 3-day PHI for succulent beans at high rate. 14-day PHI for dry beans. RUP.

Mustang Maxx® (0.8EC) at 2.72-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI for succulent beans. 21-day PHI for dry beans. RUP.

Orthene® (97S) at 0.5-1 lb. per acre. Do not feed treated vines to livestock. Not for use on snap beans. Do not exceed 2 1/8 lbs. per acre per season. 14-day PHI for dry beans. 1-day PHI for lima beans.

Sevin XLR PLUS® (4F) at 0.5-1 qt. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 14-day PHI for forage. 21-day PHI for dry legumes.

Thimet 20G® at 4.5-7.0 oz. per 1,000 linear ft. of row at any spacing. Drill granules to the side of the seed. Do not place granules in direct contact with seed. Do not feed bean foliage to livestock. 60-day PHI. RUP.

Warrior II® (2.08CS) at the following rates:
- Mexican bean beetle: 0.96-1.60 fl. oz. per acre.
- Bean leaf beetle: 1.28-1.92 fl. oz. per acre.
Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. RUP.

**Seed Corn Maggots**
Plant seed that has been treated with a product containing diazinon, or Cruiser®.

Flies are attracted to rotting organic material and freshly plowed soil. Plow winter cover crop under early in the spring and thoroughly cover. Handle seeds carefully to prevent cracking.

**Recommended Products**
- Capture LFR® at 0.2-0.39 fl. oz. per 1,000 ft. of row at planting. RUP.
- Cruiser 5FS® or Cruiser Maxx®. Rates vary by seeding rate and spacing. See labels. Cruiser® provides against early season injury by pests.
- Lorsban 4E® at 1.8 fl. oz. per 1,000 linear ft. of row. Apply at planting. RUP.

**Spider Mites**

**Recommended Products**
- Acramite 50WS® at 1-1.5 lbs. per acre. Do not exceed 2 applications per season. 3-day PHI.
- Agri-Mek 0.15EC® at 8-16 fl. oz. per acre. Dry beans only. Do not exceed 48 fl. oz. per acre per season. 7-day PHI.
- Dimethoate 4E® or Dimethoate 400® at 0.5-1 pt. per acre. Not for cowpeas. Do not feed to livestock. Do not apply during bloom. 0-day PHI for 400 (mechanical harvest only). 2-day PHI for 4E. 0-day PHI.
- Portal® (0.4EC) at 2 pts. per acre. Snap beans only. 1-day PHI.

**Stink Bugs**

**Recommended Products**
- Baythroid XL® (1EC) at 2.4-3.2 fl. oz. per acre. Dry beans and peas only. Dry beans: Do not exceed 6.4 fl. oz. per acre per season. Southern peas: Do not exceed 10.5 fl. oz. per acre per season. Southern peas: Do not exceed 10.5 fl. oz. per acre per season. 7-day PHI. Allow 14 days between applications for all labeled crops RUP.
- Brigade® (2EC) at 2.1-6.4 fl. oz. per acre (do not exceed 12.8 fl. oz per acre per season), or Brigade® (WSB) at 5.3-16 oz. per acre (do not exceed. or 32 oz. per acre per season). 3-day PHI for succulent legumes. 14-day PHI for dry legumes. RUP.

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This is a reduced-risk pesticide. See page 37 for details.
Mustang Maxx® (0.8EC) at 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI for succulent legumes. 21-day PHI for dry legumes. RUP.

Sevin XLR PLUS® (4F) at 1.5 qts. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 21-day PHI for dryed. RUP.

Warrior II® (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. RUP.

Thrips (cowpeas)

Recommended Products

Admire PRO® (4.6F) at the following rates:

Soil applications: 7-10.5 fl. oz per acre. Do not exceed 1 application per season. 21-day PHI.

Foliar applications: 1.2 fl. oz. per acre. Do not exceed 3 applications per season. 7-day PHI.

Assail 30SG® at 4.5-5.3 oz. per acre. Do not exceed 3 applications per season. 7-day PHI.

Baythroid XL® (1EC) at 1.6-2.1 fl. oz. per acre. Dry legumes only. Dry beans: Do not exceed 6.4 fl. oz. per acre per season. 7-day PHI. Southern peas: Do not exceed 10.5 fl. oz. per acre per season. 3-day PHI. Allow 14 days between applications for all labeled crops. RUP.

Brigade® (2EC) at 2.1-6.4 fl. oz. per acre, or Brigade® (WSB) at 5.3-16 oz. per acre. Do not exceed 12.8 fl. oz. of 2EC per acre per season. Do not exceed 32 oz. of WSB per acre per season. 3-day PHI for succulent legumes. 14-day PHI for dry legumes. RUP.

Entrust® (2SC) at 4.5-6 fl. oz. per acre. Succulent beans and peas: Do not exceed 29 fl. oz. per acre per season. 3-day PHI. Dry beans and peas: Do not exceed 12 fl. oz. per acre per season. 28-day PHI.

Mustang Maxx® (0.8EC) at 3.2-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI for succulent legumes. 21-day PHI for dry legumes. RUP.

Radiant SC® at 5-8 fl. oz. per acre. Succulent beans and peas: Do not exceed 28 fl. oz. per acre per season. 3-day PHI. Dry beans and peas: Do not exceed 12 fl. oz. per acre per season. 28-day PHI.

Sevin XLR PLUS® (4F) at 1 qt. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI for succulent legumes. 21-day PHI for dry legumes.

Warrior II® (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI for succulent legumes. 21-day PHI for dry legumes. RUP.

Wireworms

Recommended Products

Cruiser 5FS® or Cruiser Maxx®. Rates vary by seeding rate and spacing. See labels. Cruiser® provides against early season injury by pests.
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. “Squirrelly” mint, which occurs primarily on peppermint, is caused by the mint bud mite, *Tarsonemus pipermenthae*.

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 K₂O per acre and 50 pounds P₂O₅ per acre.

Disease Control

**Spearmint Rust, Septoria Leaf Spot**

*Recommended Products*

**Bravo®, Echo®, Equus®, and Initiate®** are labeled for use at various rates. *Indiana only.* 80-day PHI.

**Headline 2.09EC® or Headline SC®** at 9-12 fl. oz. per acre. *Rust only.* 14-day PHI.

**Propimax EC®** at 4 fl. oz. per acre. *Rust only.* 30-Day PHI.

**Quadris®** at 6.2-15.4 fl. oz. per acre. *Rust only.* 7-day PHI for processed mint.

**Rally 40WSP®** at 4-5 oz. per acre. *Rust only.* 30-day PHI.

**Verticillium Wilt**

Use wilt-resistant varieties of peppermint. Native spearmint is resistant.

Rotate plantings after no more than 3 or 4 years.

Weed Control

For specific weeds controlled by each herbicide, check Table 25 on page 66.

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**

*Recommended Products*

**Glyphosate** products 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. 7-day PHI.

**Paraquat** products at the following rates:

**Gramoxone Inteon 2L®** at 2-3 pts. per acre. Do not exceed 3 pts. per acre.

**Firestorm®** at 1.3-2 pts. per acre. Do not exceed 2 pts. per acre.

Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before crop begins to grow in spring. RUP.

**Preemergence and Early Postemergence Broadleaves and Grasses**

*Recommended Products*

**Chateau WDG®** at 2-3 oz per acre, or **Chateau SW®** at 4 oz per acre. Use NIS according to label instructions. Apply to established dormant mint. Tank-mix with paraquat (see paraquat label for rates). Adding a nitrogen source will increase activity. Do not apply to frozen ground. Has residual soil activity. Do not exceed 4 oz per acre in a single application or more than 8 oz per acre in a single growing season. Make

This is a reduced-risk pesticide. See page 37 for details.
no more than 1 sequential application of Chateau® within 60 days of first application. Applying to non-dormant mint may result in unacceptable injury. 80-day PHI.

**Sinbar 80WP** at 1-2 lbs. per acre, or 0.25-0.5 lb. per acre plus NIS or COC postemergence to the crop and small weeds. Apply before mint emerges. Do not exceed 2 lbs. per acre per season. 60-day PHI.

**Postemergence Broadleaves**

**Recommended Products**

**Bentazon** products at 0.5-1 lb. a.i. per acre. Use 4L formulations at 1-2 pts. per acre. Apply after mint and weeds have emerged. To control yellow nutsedge and Canada thistle, repeat application 7-10 days later. Crop oil will enhance activity. Do not exceed 4 pts. per acre per season.

**Moxy 2E** at 1-1.5 pts. per acre in at least 10 gals. water per acre, or **Buctril 4EC** at 8-12 fl. oz. per acre in at least 10 gals. water per acre. Apply before weeds have more than 4-6 leaves, and only on established mint that has been harvested at least one year prior to application. Buctril® may cause temporary stunting and chlorosis of mint. 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. 70-day PHI.

**Sinbar 80WP** at 0.5-1 lb. per acre. Apply up to 1 lb. product plus 1 pt. NIS per acre. Do not exceed 2 lbs. of product (pre and post) per acre per year. Discontinue use 1 year before rotating to other crops. 60-day PHI.

**Stinger 3EC** at 0.33-1 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. 45-day PHI.

**Thistrol** at 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. Bindweed suppression is best with spring application when weeds are 6-8 inches long. 40-day PHI.

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**Preemergence Broadleaves and Grasses**

**Recommended Products**

**Command 3ME** at 1.3 pts. 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. 84-day PHI.

**Devrinol 50DF-XT** at 4-8 lbs. per acre. *New plantings:* Apply soon after planting. *Established plantings:* Apply before emergence.

**Prowl H2O** at 1.5-4 pts. per acre. *Established mint only.* Use low rate on coarse soils. Apply to dormant mint before mint and weeds start to grow. 90-day PHI.

**Preemergence Broadleaves**

**Recommended Products**

**Spartan 75DF** at 3-6.7 oz. per acre. *New plantings:* Apply preemergence after planting and reduce use rate by 25% for soil type. *Established plantings:* Apply to established mint when it is dormant — in the fall after post harvest cultivation, and/or in the spring after cultivation. 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 8 oz. per 12-month period.

**Goal 2XL** at 2-3 qts. per acre in 20-40 gals. of water per acre. *Indiana only. Not for use on mineral or black sand soils.* Use 8 fl. oz. of NIS per 25 gals. of spray solution if emerged weeds are present. Apply to dormant spearmint and peppermint on muck soil (greater than 20% organic matter) before weeds are 4 inches tall. Application to emerged mint will result in severe injury.
Postemergence Grasses

Recommended Products

Assure II® at 8-12 oz. per acre. Use 1 qt. of COC per acre. Apply to actively growing grass. Do not exceed 2 applications or 30 fl. oz. per acre per season. 30-day PHI.

Poast 1.5E® at 1-1.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 2 applications per season. 20-day PHI.

Select Max® at 12-32 fl. oz. per acre, or Select 2EC® at 6-16 fl. oz. per acre. Use 1 qt. of COC per 25 gals. of spray solution (1%v/v). Spray on actively growing grass. Use at least 16 fl. oz. Select Max®, or 8 fl. oz. of Select 2EC® on established mint. Wait at least 14 days between applications. 21-day PHI.

Insect Control

Cutworms, Loopers

Recommended Products

Various Bacillus thuringiensis formulations (Agree®, Biobit®, Dipel®, Javelin®, Lepinox®, etc.) are available. Follow label rates. 0-day PHI.

Avaunt® at 3.5 oz. per acre. Do not exceed 14 oz. per acre per season. 7-day PHI.

Coragen® (1.67S) at 3.5-5 fl. oz. per acre. Do not exceed 4 applications per acre per crop. Must wait at least 14 days between applications. 3-day PHI.

Entrust® (2SC) at 4-10 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per crop. Must wait at least 4 days between treatments. 7-day PHI.

Intrepid® at 10-16 fl. oz. per acre. Do not exceed 64 fl. oz. per acre per year. 14-day PHI.

Lannate LV® at 3 pts. per acre. Do not exceed 4 applications per year and 6 pts. per acre per crop. 14-day PHI. RUP.

Lorsban Advanced® at 2-4 pts. per acre. Use lower rate when cutworm larvae are less than 0.75 inch long. Only 1 application per growing season. 90-day PHI. RUP.

Orthene 97® at 1 lb. per acre. Do not exceed 2 applications per year and 2 1/8 lbs. a.i. per acre per season. Must wait at least 7 days between applications. 14-day PHI.

Radiant SC® at 4-12 fl. oz. per acre. Do not exceed 4 applications per year and 39 fl. oz. per acre per season. Must wait 4 days between treatments. 7-day PHI.

Flea Beetles

Recommended Products

Actara® at 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. 7-day PHI.

Lannate LV® at 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. 14-day PHI. RUP.

Malathion 5EC® at 1.5 pts. per acre. For best results, apply immediately after harvest on stubble. 7-day PHI.

Mites

Recommended Products

Acramite 50WS® at 0.75-1.5 lbs. per acre. Do not exceed 1 application per season. 7-day PHI.

Agri-mek 0.15EC® at 8-12 fl. oz. per acre. Do not exceed 36 fl. oz. per acre per season. 28-day PHI. RUP.

Dicofol 4E® at 1.75-2.5 pts. per acre. Do not exceed 1 application per season. 32-day REI. 30-day PHI.

Zeal® (72WSP) at 2-4 oz. per acre. Do not exceed 1 application per season. 7-day PHI.

This is a reduced-risk pesticide. See page 37 for details.

This is a biopesticide. See page 37 for details.

Varieties of mint grown for fresh market differ from those grown for processing.
Okra

### Varieties

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Days to Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annie Oakley II (F1 Hybrid)</td>
<td>52</td>
</tr>
<tr>
<td>Clemson Spineless, (Open pollinated)</td>
<td>55</td>
</tr>
<tr>
<td>Burgundy (red)</td>
<td>60</td>
</tr>
</tbody>
</table>

### 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<sub>2</sub>O<sub>5</sub>: 0 to 200 pounds per acre. K<sub>2</sub>O: 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.

### Disease Control

**Fusarium Wilt**

Avoid fields with a history of Fusarium wilt.

Rotations of several years may reduce Fusarium wilt severity.

### Weed Control

Weeds in okra can be managed with cultivation and handweeding, 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.

For specific weeds controlled by each herbicide, check Table 25 on page 66.

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 Applications Broadleaves and Grasses

**Recommended Products**

**Glyphosate** products at 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. 14-day PHI.

### Preemergence Broadleaves and Grasses

**Recommended Products**

**Callisto**® at 6 fl. oz. per acre banded 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 3oz. per acre to weeds 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. 28-day PHI.
Dual Magnum® at 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. 60-day PHI.

Prometryn® at 0.75-1.5 pts. per acre. Apply as a directed spray to row middles at 7-9 leaf stage and when weeds are less than 2 inches tall. 14-day PHI.

Trifluralin products at 0.5-1 lb. a.i. per acre. Use 4EC formulations at 1-2 pts. 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.

Preemergence Broadleaves and Nutsedge

Recommended Products

Sandra® at 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. Do not exceed 2 oz. per acre per 12-month period.

Postemergence Broadleaves

Recommended Products

Glyphosate products. See details above for Burndown or Directed/Shielded Applications.

Postemergence Broadleaves and Grasses

Recommended Products

Aim EC®. See details above for Burndown or Directed/Shielded Applications Broadleaves.

Sandra®. See details above for Preemergence Broadleaves and Nutsedge.

Postemergence Grasses

Recommended Products

Poast 1.5E® at 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. 14-day PHI.

Insect Control

Aphids

Recommended Products

Admire PRO® (4.6F) at the following rates:

- **Soil applications**: 7-14 fl. oz. per acre. 21-day PHI.
- **Foliar applications**: 10.5 fl. oz. per acre. 0-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season. See pollinator precautions.

Assail 30SG® at 2-4 oz. per acre. Do not exceed 4 applications per season. 7-day PHI.

Beleaf® at 2.8-9.28 oz. per acre. 0-day PHI.

Malathion 5EC® at 1.5 pts. per acre. 1-day PHI.

Sivanto® (200SC) at 7-12 fl. oz. per acre. 1-day PHI.

Colorado Potato Beetles

Recommended Products

Admire PRO® (4.6F) at the following rates:

- **Soil applications**: 7-14 fl. oz. per acre. 21-day PHI.
- **Foliar applications**: 1.3-2.2 fl. oz. per acre. 0-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season.

Entrust® (2SC) at 3-6 fl. oz. per acre. Do not exceed 29 fl. oz. per acre per season. 1-day PHI.

Exirel® at 7-13.5 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per season. 1-day PHI.

Mustang Maxx® at 2.24-4 fl. oz. per acre. 1-day PHI.

Radiant SC® at 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Corn Earworms

Recommended Products

Brigade® (2EC) at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 7-day PHI. RUP.

Coragen® (1.67SC) at 3.5-5 fl. oz. per acre per season. 1-day PHI.

Entrust® (2SC) at 3-6 fl. oz. per acre. Also controls European corn borers, hornworms, armyworms, and looper. Do not exceed 29 fl. oz. per acre per season. 1-day PHI.

May be acceptable for use in certified organic production. Check with your certifier before use.
Exirel® at 7-13.5 fl. oz. per acre. Do not exceed 61 fl. oz. per acre per season. 1-day PHI.

Mustang Maxx® at 2.24-4 fl. oz. per acre. 1-day PHI.

Radiant SC® at 5-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Sevin XLR PLUS® (4F) at 1-1.5 qts. per acre. Do not exceed 6 qts. per acre per season. 3-day PHI.

Mites

Recommended Products

Acramite 50WS® at 0.75-1.5 lbs. per acre. Do not exceed 1 application per season. 3-day PHI.

Zeal (72WSP)* at 2-3 oz. per acre. Do not exceed 1 application per season. 7-day PHI.

Potato Leafhoppers

Recommended Products

Admire PRO® (4.6F) at the following rates:

Soil applications: 7-14 fl. oz. per acre. 21-day PHI.

Foliar applications: 1.3-2.2 fl. oz. per acre. 0-day PHI.

Do not exceed 0.38 lb. a.i. per acre per season. See pollinator precautions.

Thrips

Recommended Products

Admire PRO® (4.6F) at 7-14 fl. oz. per acre applied to the soil. See pollinator precautions. 21-day PHI.

Assail 30SG® at 4 oz. per acre. Do not exceed 4 applications per season. 7-day PHI.

Brigade® (2EC) at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 7-day PHI. RUP.

Entrust® (2SC) at 3-6 fl. oz. per acre. Do not exceed 29 fl. oz. of Entrust® per acre per season. 1-day PHI.

Radiant SC® at 6-10 fl. oz. per acre. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

This is a reduced-risk pesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.
Dry Bulb and Green Bunching Onion, Garlic, and Leek

<table>
<thead>
<tr>
<th>ONION Varieties</th>
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<tbody>
<tr>
<td>Bulbs</td>
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<td></td>
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<td>Green</td>
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<table>
<thead>
<tr>
<th>GARLIC Varieties</th>
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<tr>
<td>Hardneck, Porcelain group</td>
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<tr>
<td>Hardneck, Rocambole group</td>
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<tr>
<td>Hardneck, Purple Stripe group</td>
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<tr>
<td>Softneck, Artichoke group</td>
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<td>Softneck, Silverskin group</td>
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<table>
<thead>
<tr>
<th>LEEK Varieties</th>
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</thead>
<tbody>
<tr>
<td>Arkansas, Lancelot</td>
</tr>
</tbody>
</table>

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. P₂O₅: 25 to 250 pounds per acre. K₂O: 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 MnSO₄ 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. P₂O₅: 25 to 250 pounds per acre. K₂O: 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.
**Disease Control**

**Alternaria Purple Blotch and Botrytis Leaf Blight (all onion types)**
Practice 3-4 year crop rotation. Rotation out of onions or related vegetables reduces the threat of these diseases in future onion crops. Destroy cull piles. Reduce leaf wetness by ensuring adequate drainage, by spacing plants to promote air movement, and by using overhead irrigation sparingly.

**Recommended Products**
- Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. 7-day PHI for dry bulb onion and garlic. 14-day PHI for green bunching onion and leek.
- Cabrio EG® at the following rates:
  - Purple blotch: 8-12 oz. per acre.
  - Botrytis leaf blight suppression: 12 oz. per acre.
  - 7-day PHI.
- Dithane®, Manzate®, ManKocide®, and Penncozeb® are labeled at various rates for dry bulb onion and garlic. 7-day PHI.
- Endura® at 6.8 oz. per acre. 7-day PHI.
- Fontelis® at 16-24 fl. oz. per acre. 3-day PHI.
- Inspire Super® at 16-20 fl. oz. per acre. 7-day PHI for dry bulb onion and garlic. 14-day PHI for green bunching onion and leek.
- Iprodione 4L AG®, Meteor®, or Rovral 4 Flowable® at 1.5 pts. per acre See labels for tank mix instructions. 7-day PHI.
- Luna Experience® at 8-12.8 fl. oz. per acre. Supplemental label expires March 2, 2019. 7-day PHI.
- Luna Tranquility® at 16-27 fl. oz. per acre. 7-day PHI.
- Merivon® at the following rates:
  - Purple blotch: 4-11 fl. oz. per acre.
  - Botrytis leaf blight: 8-11 fl. oz. per acre.
  - 7-day PHI.
- Omega 500F® at 1 pt. per acre. Dry bulb onion and garlic only. 7-day PHI.
- Orius 3.6F® or Tebuzol 3.6F® at 4-6 fl. oz. per acre. 7-day PHI.
- Pristine 38WG® at the following rates:
  - Purple blotch: 10.5-18.5 oz. per acre.
  - Botrytis leaf blight: 14.5-18.5 oz. per acre.
  - 7-day PHI.
- Propimax EC® or Tilt® at 4-8 fl. oz. per acre. See labels for tank mix instructions. 14-day PHI for dry bulb onion.
- Quadris Flowable® at the following rates:
  - Purple blotch: 6-12 fl. oz. per acre.
  - Botrytis leaf blight: 9-15.5 fl. oz. per acre.
  - 0-day PHI.
- Quadris Opti® at 1.6-3.2 pts. per acre. 7-day PHI for dry bulb onion and garlic. 14-day PHI for green bunching onion and leek.
- Quadris Top® at 12-14 fl. oz. per acre. 7-day PHI.
- Quilt® at 14-27.5 fl. oz per acre. Purple blotch only. 0-day PHI for leek. 14-day PHI for dry bulb onion and garlic.
- Quilt Xcel® at the following rates:
  - Purple blotch: 14-21 fl. oz. per acre.
  - Botrytis leaf blight: 17.5-26 fl. oz. per acre.
  - 0-day PHI for leek. 14-day PHI for dry bulb onion and garlic.
- Rovral 4 Flowable® at 1.5 pts. per acre. Dry bulb onion and garlic only. 7-day PHI.
- Satori® at the following rates:
  - Purple blotch: 6-12 fl. oz. per acre.
  - Botrytis leaf blight: 9-15.5 fl. oz. per acre.
  - 0-day PHI.
- Scala SC® at 18 fl. oz. per acre. See label for tank mix instructions. 7-day PHI.
- Switch 62.5WG® at 11-14 oz. per acre. 7-day PHI.
- Tanos® 8 oz. per acre. Purple blotch only. 3-day PHI.
- Vangard WG® at 10 oz. per acre. 7-day PHI.

**Anthracnose (Colletotrichum coccodes)**
The pathogen that causes anthracnose also infects other crops, including tomato, pepper, and potato. Warmer temperatures (68-77°F) favor disease development. Irrigate when foliage can dry rapidly. Products labeled for Alternaria purple blotch may be helpful for anthracnose control.

**Bacterial Diseases (bacterial leaf blight, bacterial flower stalk and leaf necrosis, slippery skin, sour rot, and bulb rot)**
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 agglomera.

**Recommended Products**

- Several copper products (Badge®, Champ®, Champ-ON++, Cuprofix®, Kocide 2000®, Nu-Cop*) are labeled at various rates. See labels for rates. 0-day PHI. ManKocide* at 2.5 lbs. per acre. *Dry bulb onion only.* 7-day PHI.

**Botrytis Neck Rot (all types)**

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.

**Recommended Products**

- Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. *Dry bulb onion and garlic only.* Suppression only. 7-day PHI.

- Dithane®, Manzate®, ManKocide®, and Penncozeb® are labeled at various rates. *Dry bulb onion and garlic only.* 7-day PHI.

- Fontelis® at 16-24 fl. oz. per acre. 3-day PHI.

- Iprodione 4L AG*, Meteor®, or Rovral 4 Flowable® at 1.5 pts. per acre. See labels for tank mix instructions. 7-day PHI.

- Luna Experience* at 8-12.8 fl. oz. per acre. 7-day PHI.

- Luna Tranquility® at 16-27 fl. oz. per acre. 7-day PHI.

- Merivon® at 8-11 fl. oz. per acre. 7-day PHI.

- Omega 500F® at 1 pt. per acre. *Dry bulb onion and garlic only.* 7-day PHI.

- Pristine 38WG® at 14.5-18.5 oz. per acre. 7-day PHI.

- Quadris Opti® at 1.6-3.2 pts. per acre. 7-day PHI for dry bulb onion and garlic. 14-day PHI for leek.

**Damping-off**

Use pathogen-free sets and seed.

**Recommended Products**

- Dithane F45 Rainshield®, at 2.4 qts. per acre, or Koverall® at 3 lbs. per acre, or Manzate Max® at 1.6-2.4 qts. per acre, or Penncozeb 75DF® at 3 lbs. per acre, or Penncozeb 80WP® at 3 lbs. per acre. *Dry bulb onion and garlic only.* 7-day PHI.

- Quadris 2.08SC® at 0.4-0.8 fl oz per 1,000 row-feet preplant or at-plant. 0-day PHI.

- Ridomil Gold® SL at 0.5-1 pt. per acre.

- Satori® at 0.4-0.8 fl oz per 1,000 row-feet preplant or at-plant. 0-day PHI.

- Ultra Flourish® at 1-2 pts. per acre.

**Downy Mildew**

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.

**Recommended Products**

- Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. *Suppression only.* 7-day PHI for dry bulb onion and garlic. 14-day PHI for green bunching onion and leek.

- Catamaran® at 4-7 pts. per acre. 7-day PHI for dry bulb onion and garlic. 14-day PHI for green bunching onion and leek.

- Dithane®, ManKocide®, Manzate®, and Penncozeb® are labeled at various rates. *Dry bulb onion and garlic only.* 7-day PHI.

- Forum® at 6 fl. oz. per acre. 0-day PHI.

- Gavel 75DF® at 1.5-2 lbs. per acre. *Dry bulb onion and garlic only.* 7-day PHI.

- Omega 500F® at 1 pt. per acre. *Dry bulb onion and garlic only.* 7-day PHI.
Orondis Opti A® at 1.5 fl oz. per acre tank-mixed with Orondis Opti B® at 1.5 pt. per acre. FIFRA Section 2(ee) recommends tank mix. 7-day PHI.

Orondis Ultra A® at 1.64 fl oz. per acre tank-mixed with Orondis Ultra B® at 8 fl. oz. per acre. FIFRA Section 2(ee) recommends tank mix. 7-day PHI.

Reason® at 5.5 fl oz. per acre. 7-day PHI.

Revus 2.09SC® at 8 fl. oz. per acre. 7-day PHI.

Ridomil Gold Bravo® at 2.5 pts. per acre. 7-day PHI for dry bulb onion and garlic. 14-day PHI for green bunching onion and leek.

Ridomil Gold Copper® at 2 lbs. per acre. 10-day PHI for dry bulb onion and garlic. 7-day PHI for green bunching onion and leek.

Ridomil Gold MZ WG® at 2.5 lbs. per acre. 7-day PHI.

Zampro® at 14 fl. oz. per acre. 0-day PHI.

Zing 4.9SC® at 30 fl. oz. per acre. 7-day PHI.

Fontelis® at 24 fl. oz. as a broadcast spray or banded application at preplant or postplant for dry bulb onion. Growers in Michigan must possess Section 2(ee) label.

Smut

Rotate out of Allium species for three years where the disease is a problem.

Recommended Products

Fontelis® at 16-24 fl. oz. per acre. 3-day PHI.

Luna Experience® at 12.8 fl. oz. per acre. 7-day PHI.

Luna Tranquility® at 16-27 fl. oz. per acre. 7-day PHI.

Merivon® at 4-11 fl. oz. per acre. 7-day PHI.

Pristine 38WG® at 10.5-18.5 oz. per acre. 7-day PHI.

Quadris Top® at 12-14 fl. oz. per acre. 7-day PHI.

Switch 62.5WG® at 11-14 oz. per acre. 7-day PHI.

White Rot (Sclerotium cepivorum)

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.

Recommended Products

Fontelis® at the following rates:

Preplant or at planting for dry bulb onion: 1.2-1.6 fl. oz. per 1,000 row-feet.

All other labeled applications: 16-24 fl. oz. per acre.

3-day PHI.

Iprodione 4L AG®, Meteor®, or Rovral 4 Flowable® at 4 pts. per acre in-furrow spray preplant. 7-day PHI.

Luna Experience® at 12.8 fl. oz. per acre. Suppression only. 7-day PHI.

Luna Tranquility® at 27 fl. oz. per acre. Suppression only. 7-day PHI.

Orius 3.6F®, or Tebuzol 3.6F® at the following rates:

Preplant dry bulb onion and garlic: 20.5 fl. oz. per 4-6-inch band in-furrow.

Suppression: 4-6 fl. oz. per acre

7-day PHI.

Quadris Opti® at 1.6-3.2 pts. per acre. 7-day PHI for dry bulb onion and garlic. 4-day PHI for leek.

Quilt Xcel® at 17.5-26 fl. oz. per acre. 0-day PHI for leek. 14-day PHI for dry bulb onion and garlic.

Switch 62.5WG® at 7-14 oz. per acre. 7-day PHI.

Topsin M WSB® at 2 lbs. per acre, or Cercobin® at 43.6 fl. oz. per acre. Dry bulb onion and garlic only. 3-day PHI.
Weed Control for Garlic and Dry Bulb Onion

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 postemergent flaming.

For specific weeds controlled by each herbicide, check Table 25 on page 66.

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 Applications Broadleaves and Grasses

Recommended Products

**Gramoxone Inteon 2L** at 2.5-4 pts. per acre. Not for transplanted onions. 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 crop emergence. Do not exceed 4 pts. of Gramoxone Inteon 2L or 2 pts. of Gramoxone Max 3L per acre. RUP.

**Glyphosate** products at 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. 14-day PHI.

Postemergence Directed/Shielded Applications Broadleaves

Recommended Products

**Aim EC** at 0.5-2 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.

Preemergence Broadleaves and Grasses

Recommended Products

**Dual Magnum** at 0.67-1.3 pts. per acre. Onions in Indiana, Michigan and Ohio only. Garlic in Indiana and Ohio only. Apply postemergence starting when the crop has 2 true leaves. For dry bulb onions, a second application may be applied 21 or more days after the first. Garlic: Do not exceed one application and 1.3 pts. per acre per season. 21-day PHI. Dry bulb onions: Do not exceed 1.3 pts. per acre per application and 2.6 pts. per acre per crop and two applications per crop. 60-day PHI.

**Nortron SC** at 16-32 fl. oz. per acre. Dry bulb onions only. Not for garlic. Apply preemergence or soon after seedling before weeds germinate. May also be used postemergence, see below. Use on mineral soils only. Do not exceed 48 fl. oz. per acre per season on coarse soils and 96 fl. oz. per acre per season on medium and fine soils.

**Outlook** at 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. May be tank-mixed with other herbicides, see label. 30-day PHI.

**Pendimethalin** products. Use 3.3EC formulations at 1.2-3.6 pts. per acre, or Prowl H2O at 1.5-3 pts. per acre. Garlic: apply after planting before crop and weeds emerge, and/or apply when garlic has 1-5 true leaves. Dry bulb onions: apply when onions have 2-9 true leaves. Onions on muck soils only: apply 3.3EC formulations at up to 4.8 pts. per acre, or Prowl H2O at 4 pts. per acre after seeding and before crop emerges, after onions have 2 leaves, and if needed at 6-9 leaves. Do not exceed 14.4 pts. per acre of 3.3EC formulations or 12.5 pts. per acre of Prowl H2O on muck soils. Use low rates on coarse soils. 45-day PHI.

**Trifluralin** products at 0.375-0.625 lb. a.i. per acre. Use 4EC formulations at 0.75-1.25 pts. per acre. Dry bulb onions only. Not for garlic. Use the lowest rate on coarse soils. Apply at layby as directed spray between onion rows and incorporate. Mineral soils only. 60-day PHI.

This is a reduced-risk pesticide. See page 37 for details.
Preemergence Broadleaves

Recommended Products

Chateau WDG® 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.

Dry bulb onions: 2 oz. per acre. Apply to transplanted onions between the 2- and 6-leaf stage or to direct-seeded onions between the 3- and 6-leaf stage. Will not control emerged weeds. Wait at least 14 days between applications.

Do not exceed 2 oz. per acre per application, or 3 oz. per acre per growing season. 45-day PHI for dry bulb onions.

Preemergence Grasses

Recommended Products

Dacthal W-75® at 6-14 lbs. per acre, or Dacthal Flowable® at 6-14 pts. per acre. Onions only. Apply at seeding, transplanting, and/or layby. Preplant incorporation not recommended. May be sprayed over transplants.

Prefar 4E® at 5-6 qts. 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. Mineral soils only.

Postemergence Broadleaves

Recommended Products

Goal 2XL® at the following rates:

Seeded crops: 0.5 pt. per acre.

Transplanted crops: 1-2 pts. per acre. Use lower rate on coarse soils. Apply after direct-seeded crop has 2 true leaves, or prior to transplanting onions, or within 2 days after transplanting.

Do not exceed 2 pts. per acre. 45-day PHI for onions. 60-day PHI for garlic.

Moxy 2E® at the following rates:

Garlic: 1.5-2 pts. per acre. Apply after garlic emerges and before it is 12 in. tall. 112-day PHI for garlic.

Onions: 1-1.5 pts. per acre. Apply when onions have 2-5 true leaves, using 50-70 gals. 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.

Postemergence Grasses

Recommended Products

Clethodim products at the following rates:

Garlic: Select Max® at 9-16 fl. oz. per acre, or 2EC formulations of clethodim products at 6-8 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v).

Dry bulb onions: Select Max® at 12-32 fl. oz. per acre, or 2EC formulations of clethodim products at 6-16 fl. oz. per acre. Use 2EC formulations with 1 qt. COC per 25 gals. of spray solution (1% v/v).

Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 2 applications per season for garlic or shallots. 45-day PHI for dry bulb crops.

Fusilade DX 2E® at 10-12 fl. oz. Use 1-2 pts. of COC or 0.5-1 pt. of NIS per 25 gals. of spray solution. Apply to small actively growing grass. Do not exceed 48 fl. oz. per acre. 45-day PHI.

Poast 1.5E® at 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 4.5 pts. per acre per season. 30-day PHI.

Weed Control for Leek and Green Onion

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 flamener 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 based of larger plants — even though some crop injury is likely with postemergent flaming.

For specific weeds controlled by each herbicide, check Table 25 on page 66.
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 Applications**

**Broadleaves and Grasses**

**Recommended Products**

**Gramoxone Inteon 2L** at 2.5-4 pts. per acre. *Direct-seeded onions only. Not for transplants or sets.* 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 crop emergence. Do not exceed 4 pts. of Gramoxone Inteon 2L* or 2 pts. of Gramoxone Max 3L* per acre. *RUP.*

**Glyphosate** products at 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 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. See label for suggested application volume and adjuvants. 14-day PHI.

**Premergence Broadleaves and Grasses**

**Recommended Products**

**Dual Magnum®** at 0.67-1.3 pts. per acre. *Green onions in Indiana, Michigan, and Ohio only. Not for leeks.* Apply preemergence starting when the crop has 2 true leaves. Do not exceed one application and 1.3 pts. per acre per season. 21-day PHI.

**Outlook** at 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. May be tank-mixed with other herbicides, see label. 30-day PHI.

**Prowl H2O®** at 2 pts. per acre. *Use only on muck soils (organic matter greater than 20%) or on mineral soils with greater than 3% organic matter.* Apply after seeding before crop emerges, or apply when crop has 2 to 3 true leaves. If both pre and post applications are used, wait 30 days before preemergence application before applying postemergence. Do not exceed 2 pts. per acre per application or 4 pts. per acre per season. 30-day PHI.

**Postemergence Broadleaves**

**Recommended Products**

**Aim EC®** at 0.5-2 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.

**Moxy 2EC®** at 1-1.5 pts. per acre. *Onions only. Not for leeks.* Apply when onions have 2-5 true leaves, using 50-70 gals. 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.

**Postemergence Grasses**

**Recommended Products**

**2EC formulations of clethodim products** at 6-8 fl. oz. per acre. Use with 1 qt. COC per 25 gals. of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. 14-day PHI.

**Poast 1.5E®** at 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 4.5 pts. per acre per season. 30-day PHI.
<table>
<thead>
<tr>
<th>Product (REI/PHI)</th>
<th>Common Name</th>
<th>Timing and Application Location Relative to Crop</th>
<th>Incorporated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aim EC* (12h/-)</td>
<td>carfentrazone</td>
<td>Before seeding</td>
<td>X</td>
</tr>
<tr>
<td>Chateau* (24h/45d)</td>
<td>flumioxazin</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Dacthal W-75*, Dacthal* flowable (12h/-)</td>
<td>DCPA</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Dual Magnum* (24h/21d)</td>
<td>s-metolachlor</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fusilade* (12h/45d)</td>
<td>fluazifop</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Goal* (12h/45d to 60d)</td>
<td>oxyfluorfen</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Gramoxone Inteon 2L* (12h to 24h/-)</td>
<td>paraquat</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Moxy* (12h/112d)</td>
<td>bromoxynil</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nortron* (12h/)</td>
<td>norflurazin</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Outlook* (12h/30d)</td>
<td>dimethenamid-P</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Prowl H2O* (24h/30d)</td>
<td>pendimethalin</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Poast* (12h/30d)</td>
<td>sethoxydim</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Prefar 4E (12/-)</td>
<td>bensulide</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Roundup*, others (12h/)</td>
<td>glyphosate</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Select Max*, others (12h/14d to 45d)</td>
<td>clethodim</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Treflan*, others (12h/60d)</td>
<td>trifluralin</td>
<td>X</td>
<td>yes</td>
</tr>
</tbody>
</table>

1For effectiveness against specific weeds, see Table 25 on page 66, 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.
2X=permitted for at least one crop.
3X=may be used for that crop. *=Direct-seeded crops only.
Insect Control

Onion Maggots (dry bulb)

**Recommended Products**
- **FarMore FI500®** commercial seed treatment.
- **Sepresto®** commercial seed treatment is part of the CAPS treatment, which is available only on Nunhems varieties.
- **Lorsban 4E®** at 1.1 fl. oz. per 1,000 linear ft. of row, or Lorsban 75WG® at 0.73 oz. per 1,000 linear ft. of row as an in-furrow drench at planting. Use a minimum of 40 gals. of total drench per acre. Limit of 1 application per year. RUP.

Onion Maggots (dry bulb and green bunching)

**Recommended Products**
- **Ambush 2EC®** at 6.4-19.2 fl. oz. per acre. *Adult control.* Do not exceed 2 lbs. a.i. per acre per season. 1-day PHI. RUP.
- **Diazinon AG500®** at 2-4 qts. per acre, or Diazinon 50W® at 4-8 lbs. per acre. Broadcast just before planting and mix into the top 3-4 inches of soil. Apply in sufficient water to drench seed furrow planting. Do not exceed 3 foliar applications per season. 14-day PHI. RUP.
- **Mustang Maxx®** (0.8EC) at 2.24-4 fl. oz. per acre. *Adult control.* Do not exceed 20 fl. oz. per acre per season. Add COC at 16 fl. oz. per acre. 7-day PHI. RUP.
- **Pounce 25WP®** at 6.4-19.2 fl. oz. per acre. *Adult control.* Do not exceed 8 lbs. per acre per season. 1-day PHI. RUP.
- **Warrior II®** (2.08EC) at 0.96-1.6 fl. oz. per acre. *Adult control.* Do not exceed 15.36 fl. oz. per acre per season. 14-day PHI. RUP.

Onion Thrips (dry bulb, green bunching, garlic, and leeks)

Field site selection. Onion thrips build to high levels in small grains and move to onions when small grains dry down or are harvested. Avoid planting next to small grains.

Plant resistant/tolerant varieties. Tolerant varieties include White Keeper, El Charro, Snow White, Vega, X201, and Zapotec.

**Recommended Products**
- **Assail 30SG®** at 5-8 oz. per acre. Do not exceed 4 applications per season. Many onion thrips populations have developed resistance to this insecticide so efficacy will vary. 7-day PHI.
- **Entrust®** (2SC) at 4.8 fl. oz. per acre. 1-day PHI.
- **Exirel®** (0.83E) at 13.5-20.5 fl. oz. per acre. 1-day PHI.
- **Movento®** (2SC) at 5 fl. oz. per acre. Do not exceed 2 applications per year. Apply with a nonionic surfactant (0.25-0.5% v/v). Apply in June or early July, when thrips threshold reaches 1 thrips per leaf in the field for the first time in the season. After making two applications about 7 days apart, rotate to an insecticide with a different mode of action for managing insecticide resistance. 3-day PHI.
- **Radiant SC®** at 6-10 fl. oz. per acre. Do not exceed 30 fl. oz. per acre per season. Do not make more than 5 applications per calendar year. Do not make more than 2 consecutive applications for insecticide resistance management purposes. Apply when onion thrips reach 3 thrips per leaf. 30-day PHI. RUP.

**Onion Thrips (dry bulb and garlic)**

**Recommended Products**
- **Agri-Mek®** (0.15 EC) at 8.16 fl. oz. per acre. Do not exceed 48 fl. oz. per acre per season. Use when thrips reach 1 thrips per leaf threshold. Make 2 consecutive applications 7-days apart, then rotate to an insecticide with different mode of action. 30-day PHI. RUP.
- **Ambush 2EC®** at 9.6-19.2 fl. oz. per acre. Use when thrips first appear. *Not for rescue treatments.* Do not exceed 2 lbs. a.i. per acre per season. Many onion thrips populations have developed resistance to this insecticide so efficacy will vary. 1-day PHI. RUP.
- **Pounce 25WP®** at 9.6-19.2 oz. per acre. Many onion thrips populations have developed resistance to this insecticide so efficacy will vary. 1-day PHI. RUP.
- **Warrior II®** (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 15.36 fl oz. per acre per season. Many onion thrips populations have developed resistance to this insecticide so efficacy will vary. 14-day PHI. RUP.

**Onion Thrips (dry bulb and green bunching)**

**Recommended Products**
- **Lannate LV®** (2.4WSL) at 3 pts. per acre. *Green onion:* Do not exceed 18 pts. per acre. *Dry bulb:* Do not exceed 12 pts. per acre. 7-day PHI. RUP.
Example of Insecticide Rotation for Onion Thrips Management

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. Note: Only apply Exirel® a maximum of two back-to-back applications during the season.

<table>
<thead>
<tr>
<th>Week</th>
<th>Product</th>
<th>Action Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Movento®</td>
<td>1 thrips/leaf</td>
</tr>
<tr>
<td>2</td>
<td>Movento®</td>
<td>1 thrips/leaf</td>
</tr>
<tr>
<td>3</td>
<td>Agri-Mek® or Exirel®</td>
<td>1 thrips/leaf</td>
</tr>
<tr>
<td>4</td>
<td>Agri-Mek® or Exirel®</td>
<td>1 thrips/leaf</td>
</tr>
<tr>
<td>5</td>
<td>Radiant®</td>
<td>3 thrips/leaf</td>
</tr>
<tr>
<td>6</td>
<td>Radiant®</td>
<td>3 thrips/leaf</td>
</tr>
<tr>
<td>7</td>
<td>Lannate® or Exirel®</td>
<td>1 thrips/leaf</td>
</tr>
<tr>
<td>8</td>
<td>Lannate® or Exirel®</td>
<td>1 thrips/leaf</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>IRAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiant SC®</td>
<td>spinetoram</td>
<td>5</td>
</tr>
<tr>
<td>Lannate LV®</td>
<td>methomyl</td>
<td>1A</td>
</tr>
<tr>
<td>Agri-Mek SC®</td>
<td>abamectin</td>
<td>6</td>
</tr>
<tr>
<td>Movento®</td>
<td>spirotetramat</td>
<td>23</td>
</tr>
<tr>
<td>Exirel®</td>
<td>cyantraniliprole</td>
<td>28</td>
</tr>
</tbody>
</table>
## Potato

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Season</th>
<th>Use</th>
<th>Scab Resistance</th>
<th>Appearance and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark Red Norland</td>
<td>very early</td>
<td>market, home</td>
<td>good</td>
<td>Dark, deep red; smooth skinned; shallow eyes medium in number</td>
</tr>
<tr>
<td>Red Norland</td>
<td>very early</td>
<td>market, home</td>
<td>good</td>
<td>Bright red, oblong, smooth skinned, shallow eyes medium in number</td>
</tr>
<tr>
<td>Superior</td>
<td>early</td>
<td>chips, market</td>
<td>very good</td>
<td>White, slight russet, oval, very popular</td>
</tr>
<tr>
<td>Russet Norkotah</td>
<td>early</td>
<td>market, home</td>
<td>fair</td>
<td>Very good appearance, good baking quality, fair specific gravity</td>
</tr>
<tr>
<td>Cascade</td>
<td>mid-season</td>
<td>market, home</td>
<td>good</td>
<td>White, round</td>
</tr>
<tr>
<td>Goldrush</td>
<td>mid-season</td>
<td>market, home</td>
<td>fair</td>
<td>Very good appearance, good baking quality, fair specific gravity</td>
</tr>
<tr>
<td>Snowden</td>
<td>mid-season</td>
<td>chips, market</td>
<td>good</td>
<td>White, very high dry matter, ideal for baking and French fries; exceptional ability to produce white potato chips; tubers sometimes rough</td>
</tr>
<tr>
<td>Atlantic</td>
<td>late</td>
<td>chips, market</td>
<td>good</td>
<td>White, blocky-round, high yield; hollow heart, internal browning, high specific gravity</td>
</tr>
<tr>
<td>Katahdin</td>
<td>late</td>
<td>market, home</td>
<td>fair</td>
<td>White, smooth, round, shallow-eyed</td>
</tr>
<tr>
<td>Kennebec</td>
<td>late</td>
<td>market, home</td>
<td>fair</td>
<td>White, long, oval</td>
</tr>
<tr>
<td>Red Pontiac</td>
<td>late</td>
<td>home garden</td>
<td>fair</td>
<td>Red, round, very high yield, low specific gravity, good boiling, mashing type</td>
</tr>
<tr>
<td>Russet Burbank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>For trial only</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conestoga</td>
<td>early</td>
<td></td>
<td></td>
<td>A white type with good shelf life, shape, and baking quality</td>
</tr>
<tr>
<td>Somerset</td>
<td>mid-season</td>
<td></td>
<td></td>
<td>Blocky, very good appearance, high specific gravity, chips well, white</td>
</tr>
<tr>
<td>Yukon Gold</td>
<td>early</td>
<td>local market, home</td>
<td></td>
<td>Yellow flesh, good size</td>
</tr>
<tr>
<td>Russian Banana</td>
<td>late</td>
<td>specialty markets</td>
<td>good</td>
<td>Long, narrow fingerling; pale yellow flesh</td>
</tr>
<tr>
<td>Carola</td>
<td>late</td>
<td>specialty markets</td>
<td>good</td>
<td>Yellow skin and flesh, oval</td>
</tr>
</tbody>
</table>

### 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$_2$O$_5$: none — apply 50 to 150 pounds as a starter depending on the soil test results. K$_2$O: 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$_2$O 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

<table>
<thead>
<tr>
<th>Vine Killing Product</th>
<th>Treatment</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defol 750®</td>
<td>3.2 qts. per acre in 10-20 gals. water by ground or 5-10 gals. by air.</td>
<td>Apply 10 days before harvest. Do not apply in extreme heat during middle of the day.</td>
</tr>
<tr>
<td>paraquat</td>
<td>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. <strong>Not for potatoes to be stored or used for seed.</strong></td>
<td>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.</td>
</tr>
<tr>
<td>Reglone®</td>
<td>1-2 pts. in 20-100 gals. water plus 8-64 fl. oz. nonionic surfactant.</td>
<td>A second application can be made if necessary. Allow at least 5 days between applications. 7-day PHI.</td>
</tr>
<tr>
<td>Rely 200®</td>
<td>29 fl. oz. per acre.</td>
<td>Do not make more than 1 application. 9-day PHI.</td>
</tr>
</tbody>
</table>

### 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.

### Disease Control

#### Black Dot

**Recommended Products**

- Bravo®, Echo®, and Equus® and are labeled for use at various rates. 7-day PHI.
- Headline SC® at 6-9 fl. oz. per acre. 3-day PHI.
- Luna Tranquility® at 11.2 fl. oz. per acre. 7-day PHI.
- Quadris® at 6-15.5 fl. oz. per acre. 14-day PHI.
- Revus Top 2.08SC® at 5.5-7.0 fl. oz. per acre. 14-day PHI.
- Satori® at 6-15.5 fl. oz. per acre. 14-day PHI.
- Tanos® at 6-8 oz per acre. *Disease suppression only.* 14 day PHI.
- Zing 4.9SC® at 32-34 fl. oz per acre. 7 day PHI.

#### Black Leg

Plant cut seed tubers that have been stored under conditions for rapid healing of cut surfaces and treated with a labeled potato seed treatment. Plant whole seed tubers where possible.

#### Black and Silver Scurf

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.

**Recommended Products**

- Evolve® at 0.75 lb. per cwt.
- Moncut 75DF® at 0.7-1.1 lbs. per acre.
- Quadris F® at 0.4-0.8 fl. oz. per 1,000 ft. of row in furrow.
- Satori® at 0.4-0.8 fl. oz. per 1,000 ft. of row in furrow.
- Tops MZ® at 0.75-1 lb. per cwt.

#### Early Blight

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 Table 29 (page 76) for more information.
**Recommended Products**

**Bravo**, **Echo**, and **Equus** are labeled for use at various rates. 7-day PHI.

**Endura 70WG** at 3.5-4.5 oz. per acre. 10-day PHI.

**Gavel 75DF** at 1.5-2 lbs. per acre. 14-day PHI.

**Gem 500SC** at 2.9-3.8 fl. oz. per acre. 7-day PHI.

**Headline** at 6-9 oz. per acre. 3-day PHI.

**Luna Tranquility** at 11.2 fl. oz. per acre. 7-day PHI.

**Dithane**, **Manzate**, and **Penncozeb** are labeled for use at various rates. 14-day PHI.

**Quadris 2.08SC** at 6.0-15.5 fl. oz. per acre. 14-day PHI.

**Quadris Opti** at 1.6 pts. per acre. 14-day PHI.

**Revus Top 2.08SC** at 5.5-7 fl. oz. per acre. 14-day PHI.

**Rovral** at 1-2 pts. per acre 14-day PHI.

**Satori** at 6-15.5 fl. oz. per acre. 14-day PHI.

**Scala** at 7 fl. oz. per acre. 7-day PHI.

**Tanox 50WDG** at 6 oz. per acre. 14-day PHI.

**Zing 4.9SC** at 32-34 fl. oz per acre. 7 day PHI.

**Fusarium Dry Rot**

Avoid bruising at harvest. Cure potatoes in storage at 60°F before lowering temperature. Provide adequate ventilation.

**Recommended Products**

**Manzate FL** at 1 qt. per 50 gals. water. Dip whole or cut potatoes in solution.

**Mertect 340-F** at 0.42 oz. per 2,000 lbs. of tubers.

**Late Blight**

Destroy all potato cull piles.

The fungus that causes late blight does not overwinter in areas where hard freezes are characteristic. The fungus must be re-introduced on winds or plant material each year.

**Recommended Products**

**Bravo**, **Echo**, and **Equus** are labeled for use at various rates. 7-day PHI.

**Curzate 60DF** at 3.2 oz. per acre. 14-day PHI.

**Gavel 75DF** at 1.5-2 lbs. per acre. 14-day PHI.

**Dithane**, **Manzate**, and **Penncozeb** are labeled for use at various rates. 14-day PHI.

**Orondis Ultra**. Follow rates given on each multi-pack container. Apply as tank-mix of both products in multi-pack. 7-day PHI.

**Omega 500F** at 5.5 fl. oz. per acre. 14-day PHI.

**Previcur Flex** at 0.7-1.2 pts. per acre. 14-day PHI.

**Ranman 400SC** at 1.4-2.75 fl. oz. per acre. 7-day PHI.

**Revus Top 2.08SC** at 5.5-7 fl. oz. per acre. 14-day PHI.

**Tanox 50 WDG** at 6-8 oz per acre. 14-day PHI.

**Zampro** at 11-14 fl. oz per acre. 4-day PHI.

**Zing 4.9SC** at 32-34 fl. oz per acre. 7 day PHI.

**Ring Rot**

Use certified disease-free seed. When cutting seed stock, the cutter should be periodically cleaned and disinfected, especially when changing seed lots.

The ring rot bacterium is easily spread. Although this bacterium will not survive more than 1 year in the soil (and thus can be controlled by crop rotation), a farm with ring rot must conduct a thorough clean-up before bringing in seed for the next year’s crop. The organism can easily survive the winter in crop debris or soil on storage walls; seed cutters, bin pilers, graders, and other handling equipment; tractors, fork lifts and other vehicles; and on burlap sacks, wooden boxes, or other containers. If clean seed potatoes contact any of these contamination sources, the problem can recur.

The first step is to clean all contaminated surfaces with hot soapy water to remove all soil and debris. Use steam or water under pressure. However, this alone will not eliminate the bacterium. The surfaces then must be treated with a disinfectant.


**Root Knot and Lesion Nematodes**

Sample fields during growing season for parasitic nematodes before planting. Avoid fields with high numbers of root knot and/or lesion nematodes. Methyl bromide and sodium methyl dithiocarbamate give best results when nematode populations are moderate to high. Vydate® gives adequate control when nematode populations are low to moderate. Vydate® and methyl bromide formulations are RUPs.

**Scab**

Plant resistant varieties. Maintain high moisture levels (near field capacity) during tuber set and enlargement. Do not apply manure or other organic matter immediately before planting. Avoid excessive liming, and maintain acid soil pH. Follow 3-4 year rotation schedule.

This is a reduced-risk pesticide. See page 37 for details.
**Seed Piece Decay**  
Plant seed pieces that are suberized. Warm seed tubers to 50°F before cutting; keep all equipment sanitized. Plant when soil temperatures are at least 45°F. Treat seed pieces with a registered fungicide when appropriate.

**Recommended Products**  
Formulations of Dithane®, Manzate®, and Pencozeb® are labeled at various rates. Evolve® or Tops MZ® at 0.75 lb per cwt. Maxim® at 0.5 lb. per cwt.

**Verticillium Wilt**  
Employ at least a 2-year rotation with small grains to manage fungus populations in the soil.

Good weed control also is important in reducing pathogen populations. Choose potato varieties that have partial resistance to Verticillium wilt.

**Virus Diseases and Purple-Top Wilt (aster yellows)**  
Plant only certified seed tubers. Practice clean cultivation. Rogue first infected plants, including tubers. Control aphids and leafhoppers with insecticides.

**White Mold**  
Avoid excess nitrogen. Reduce overhead irrigation if disease is present.

**Recommended Products**  
Contans WG® at 1-4 lbs. per acre. Apply immediately after harvest or 3-4 months before planting. Endura® at 5.5-10 oz. per acre. 10-day PHI. Luna Tranquility® at 11.2 fl. oz. per acre. 7-day PHI. Omega 500F® at 5.5-8 fl. oz. per acre. 14-day PHI. Rovral® at 2 pts. per acre. 14-day PHI. Topsis FL® at 20-30 fl. oz. per acre. 21-day PHI.

**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 Table 25 on page 66.

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 Applications Broadleaves and Grasses**

**Recommended Products**  
Gramoxone Inteon 2L® at 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. RUP.

Glyphosate products at 0.75-2.75 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. 14-day PHI.

**Preemergence Broadleaves and Grasses**

**Recommended Products**  
Aim EC® at 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. 7-day PHI.

**Eptam 7E®** at 3.5-7 pts. per acre, or **Eptam 20G®** at 15-20 lbs. per acre. Apply before planting, after

This is a reduced-risk pesticide. See page 37 for details.
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. 45-day PHI.

Linuron® 50DF products at 1.5-3 lbs. per acre, or 4L products 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.

Matrix 25DF® at 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. 60-day PHI.

Metribuzin® 4F products at 0.5-2 pts. per acre, or 75DF products 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. 60-day PHI.

Outlook® at 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. 40-day PHI.

Pendimethalin products at the following rates:

- **3.3EC formulations** at 1.2-3.6 pts. per acre.
- **Prowl H2O®** at 1.5-3 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.

Trifluralin products at 0.5-1 lb. a.i. per acre. Use 4EC formulations at 1-2 pts. per acre, or 60DF formulations at 0.8-1.7 lbs. per acre. Use low rate on soils with less than 2% organic matter. Broadcast and incorporate after planting but before emergence, immediately after drag-off, or after potatoes have fully emerged. Not effective on muck or high organic matter soils.

**Preemergence Broadleaves**

**Recommended Products**

- **Chateau 51WDG®** at 1.5 oz. per acre to soil covered potato. *Minnesota only.* 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. No PHI listed.

League® at 4-6.4 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 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. 45-day PHI.

Reflex® at 1 pt. per acre. Broadcast after planting and before potatoes emerge. When using on any variety for the first time, first determine whether 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. 70-day PHI.

**Postemergence Broadleaves and Grasses**

**Recommended Products**

- **Linuron** products. See details See details above for Preemergence Broadleaves and Grasses.

- **Matrix 25DF®**. See details above for Preemergence Broadleaves and Grasses.

**Postemergence Broadleaves**

**Recommended Products**

- **Aim EC®** See details above for Burndown or Directed/ Shielded Applications Broadleaves.

- **League®**. See details above for Preemergence Broadleaves.

- **Metribuzin** products. See details above for Preemergence Broadleaves and Grasses.
### Postemergence Grasses

**Recommended Products**

Clethodim products at the following rates:

- **Select Max®** at 9-32 fl. oz. per acre.

**2EC formulations of clethodim products** at 6-16 fl. oz. per acre.

Use 1 qt. of COC per 25 gals. of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. 30-day PHI.

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### Herbicides for Potatoes

**Postemergence Grasses**

**Recommended Products**

Clethodim products at the following rates:

- **Select Max®** at 9-32 fl. oz. per acre.

**2EC formulations of clethodim products** at 6-16 fl. oz. per acre.

Use 1 qt. of COC per 25 gals. of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. 30-day PHI.

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<table>
<thead>
<tr>
<th>Product (REI/PHI)</th>
<th>Common Name</th>
<th>Timing and Application Location Relative to Crop</th>
<th>Timing Relative to Weeds</th>
<th>Weed Groups Controlled</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timing and Application Location</strong></td>
<td>Before planting</td>
<td>After planting before grounds cracks</td>
<td>At/after Drag-off</td>
<td>At/after hilling</td>
<td>Between rows, directed/shielded</td>
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<td><strong>Product</strong></td>
<td><strong>Relative to Weeds</strong></td>
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<td><strong>Comments</strong></td>
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*For effectiveness against specific weeds, see Table 25 on page 66, 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. X= permitted on label.*
Insect Control

Aphids (green peach aphid, melon aphid, potato aphid, and others)

Conserve natural enemies. Limiting insecticide use will conserve predators and parasites that help control aphid populations.

Recommended Products

Soil-applied or seed piece treatment materials:

Admire PRO® (4.6F) at 5.7-8.7 fl. oz. per acre. Apply directly to seed piece or below seed piece at planting. Can expect 70-90 days of control. Do not exceed 0.31 lb. a.i. per acre per season. See pollinator precautions.

Belay® at 0.4-0.6 fl. oz. per 100 lbs. of seed, or 9-12 fl. oz per acre at planting. See label for application methods. 14-day PHI.

Cruiser 5FS® or Cruiser Maxx®. Rates vary according to seeding rate and row spacing. See labels. For best results plant potatoes immediately after treatment.

Platinum 2SC® at 5-8 fl. oz. per acre (do not exceed 8 fl. oz. per acre per season), or Platinum Ridomil Gold® at 2.2 fl. oz. per 1,000 linear ft. of row (do not exceed 38 fl. oz. per acre per season). Apply directly to seed piece in sufficient water to cover entire seed piece. Can expect 90-100 days control. See pollinator precautions.

Sivanto® at 7-10.5 fl. oz. per acre.

Thimet 20G® at the following rates:
- Light or sandy soils: 8.5-11.3 oz. per 1,000 linear ft. of row for any spacing (minimum 32-inch spacing).
- Heavy or clay soils: 13.0-17.3 oz. per 1,000 linear ft. of row.

Apply as a band application on each side of row and beneath the soil surface, or in the seed furrow. 90-day PHI. RUP.

Foliar-applied materials:

Actara® (25WDG) at 3 oz. per acre. Do not exceed 6 oz. per acre per season. See pollinator precautions. 14-day PHI.

Admire PRO® (4.6F) at 1.3 fl. oz. per acre. Do not exceed 5.6 fl. oz. per acre per season. See pollinator precautions. 7-day PHI.

Ambush® at 3.2-12.8 oz. per acre. 14-day PHI. RUP.

Asana XL® at 5.8-9.6 fl. oz. per acre. 7-day PHI. RUP.

Assail 30SG® at 2.5-4 oz. per acre. Do not exceed 4 applications per year. 7-day PHI.

Athena® at 7-17 fl. oz. per acre. 21-day PHI. RUP.

Belay® (2.13SC) at 2-3 fl. oz. per acre. See pollinator precautions. 14-day PHI.

Beleaf 50SG® at 2-2.8 oz. per acre. 7-day PHI.

Dimethoate 400® or Dimethoate 4E® at 0.5-1 pt. per acre, or Dimethoate 2.67EC® at 0.75-1.5 pts per acre. 0-day PHI for Dimethoate 400® and Dimethoate 2.67EC®, 2-day PHI for Dimethoate 4E®.

Fulfill® (50WDG) at 2.75-5.5 oz. per acre. Requires up to 7 days to see results. Best control achieved with more than 10 gals. of water per acre. Do not exceed 11 oz. per acre per season. 14-day PHI.

Lannate LV® (2.4WSL) at 1.5-3 pts. per acre. Do not exceed 15 pts. per acre per season. 6-day PHI. RUP.

M-Pede® at 1-2% by volume. Must contact aphids to be effective. 0-day PHI.

Movento® (2SC) at 4-5 fl. oz. per acre. Do not exceed 10 fl. oz. per acre per season. 7-day PHI.

Pyreneone® at 1-12 fl. oz. per acre. 0-day PHI.

Sivanto® (200SL) at 7-10.5 fl. oz. per acre. 7-day PHI.

Torac® (1.29EC) at 17-21 fl. oz. per acre. Do not exceed 2 applications per season. See pollinator precautions. 14-day PHI.

Transform WG® at 1.5-2.25 oz. per acre. Do not apply more 8.5 oz per acre per year. 7-day PHI.

Voliam Flexi® at 4 oz. per acre. 14-day PHI.

Vydate C-LV® at 17-34 fl. oz. per acre, or Vydate L® at 2-4 pts. per acre. Do not exceed 198 fl. oz. of Vydate C-LV® or 24 pts. of Vydate L® per acre per season. 7-day PHI. RUP.

Warrior II® (with Zeon Technology) at 1.28-1.92 fl. oz. per acre, or Warrior® (with Zeon Technology) at 2.56-3.84 fl. oz. per acre. 7-day PHI. RUP.

Colorado Potato Beetles

Allowable Defoliation From Colorado Potato Beetles

Preflowering: 20-30%.

Flowering: 5-10%.

Tuber Formation: 30%.

Manage resistance. See Colorado Potato Beetle Resistance Management on page 196.

Practice crop rotation. Planting fields as far as possible from last year’s potato fields will reduce potato beetle damage.

Regular (weekly) field scouting will allow you to determine the necessity for, and improve the timing of, insecticide treatments.

This is a reduced-risk pesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.
Potato - Insect Control

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 neonirotinoids (Admire Pro®, Gaucho®, Genesis®, Platinum®) are used, foliar neonirotinoids (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.

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Active Ingredient</th>
<th>Chemical Class</th>
<th>IRAC Group Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actara*</td>
<td>thiamethoxam</td>
<td>neonicotinoid</td>
<td>4A</td>
</tr>
<tr>
<td>Platinum*</td>
<td>thiamethoxam</td>
<td>neonicotinoid</td>
<td>4A</td>
</tr>
<tr>
<td>Admire Pro*</td>
<td>imidacloprid</td>
<td>neonicotinoid</td>
<td>4A</td>
</tr>
<tr>
<td>Assail*</td>
<td>acetamiprid</td>
<td>neonicotinoid</td>
<td>4A</td>
</tr>
<tr>
<td>Belay*</td>
<td>clothianidin</td>
<td>neonicotinoid</td>
<td>4A</td>
</tr>
<tr>
<td>Genesis*</td>
<td>imidacloprid</td>
<td>neonicotinoid</td>
<td>4A</td>
</tr>
<tr>
<td>Gaucho*</td>
<td>imidacloprid</td>
<td>neonicotinoid</td>
<td>4A</td>
</tr>
<tr>
<td>Leverage*</td>
<td>imidacloprid + cyfluthrin</td>
<td>neonicotinoid + pyrethroid</td>
<td>4A + 3</td>
</tr>
<tr>
<td>Endigo ZC*</td>
<td>thiamethoxam = lambda cyhalothrin</td>
<td>neonicotinoid + pyrethroid</td>
<td>4A + 3</td>
</tr>
<tr>
<td>Baythroid XL*</td>
<td>cyfluthrin</td>
<td>pyrethroid</td>
<td>3</td>
</tr>
<tr>
<td>Ambush*</td>
<td>permethrin</td>
<td>pyrethroid</td>
<td>3</td>
</tr>
<tr>
<td>Pounce*</td>
<td>permethrin</td>
<td>pyrethroid</td>
<td>3</td>
</tr>
<tr>
<td>Warrior II*</td>
<td>lambda cyhalothrin</td>
<td>pyrethroid</td>
<td>3</td>
</tr>
<tr>
<td>Agri-Mek*</td>
<td>abamectin</td>
<td>GABA agonist</td>
<td>6</td>
</tr>
<tr>
<td>Epi-Mek*</td>
<td>abamectin</td>
<td>GABA agonist</td>
<td>6</td>
</tr>
<tr>
<td>Monitor*</td>
<td>methomidaphos</td>
<td>organophosphate</td>
<td>1B</td>
</tr>
<tr>
<td>Kryocide®, Cryolite*</td>
<td>sodium aluminofluoride</td>
<td>mineral</td>
<td>9A</td>
</tr>
<tr>
<td>M-Trak®, Novodor*, Raven*</td>
<td>Bacillus thuringiensis</td>
<td>bacterium</td>
<td>11C</td>
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<tr>
<td>Entrust*</td>
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<td>spinosyn</td>
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<td>Radiant*</td>
<td>spinetoram</td>
<td>spinosyn</td>
<td>5</td>
</tr>
<tr>
<td>Rimon*</td>
<td>novaluron</td>
<td>chitin biosynthesis inhibitor</td>
<td>15</td>
</tr>
<tr>
<td>Torac*</td>
<td>tolfenpyrad</td>
<td>mitochondrial complex I electron transport inhibitors</td>
<td>21A</td>
</tr>
<tr>
<td>Coragen*</td>
<td>chlorantraniliprole</td>
<td>anthanilic diamide</td>
<td>28</td>
</tr>
<tr>
<td>Voliam Flexi*</td>
<td>chlorantraniliprole + thiamethoxam</td>
<td>anthanilic diamide + neonicotinoid</td>
<td>28 + 4A</td>
</tr>
<tr>
<td>Voliam Xpress*</td>
<td>chlorantraniliprole + lambda cyhalothrin</td>
<td>anthanilic diamide = pyrethroid</td>
<td>28 + 3</td>
</tr>
</tbody>
</table>
Recommended Products

Soil-applied or seed piece treatments:

Admire PRO® (4.6F) at 0.17-0.35 fl. oz. per 100 lbs. of seed, or 5.7-8.7 fl. oz. per acre. Apply directly to seed piece or below seed piece at planting. Can expect good control of first generation potato beetle and 70-90 days of aphid control. Do not exceed 0.31 lb. a.i. per acre per season. See pollinator precautions.

Belay® at 0.4-0.6 fl. oz. per 100 lbs. of seed, or 9-12 fl. oz. per acre at planting. See label for application methods. 14-day PHI.

Cruiser 5FS® or Cruiser Maxx®. Rates vary according to seeding rate and row spacing. See labels. For best results plant potatoes immediately after treatment.

Platinum® (2SC) at 5-8 fl. oz. per acre, or Platinum Ridomil Gold® at 2.2 fl. oz. per 1,000 linear ft. of row. Apply directly to seed piece in sufficient water to cover entire seed piece. Provides seasonlong control of potato beetles and aphids at higher label rates. Do not exceed 8.0 fl. oz. of Platinum 2SC®, or 38 fl. oz. of Platinum Ridomil Gold® per acre per season. See pollinator precautions.

Scorpion 35SL® at 11.5-13.25 fl. oz. per acre.

Sivanto® at 10.5-14 fl. oz. per acre.

Thimet 20G® at the following rates:
- Light or sandy soils: 8.5-11.3 oz. per 1,000 linear ft. of row for any spacing (minimum 32-inch spacing).
- Heavy or clay soils: 13.0-17.3 oz. per 1,000 linear ft. of row.

Apply as a band application on each side of row and beneath the soil surface or in the seed furrow. 90-day PHI. RUP.

Vydate C-LV® at 8.5-34 fl. oz. per acre (Do not exceed 198 fl. oz. per acre per season), or Vydate L® (2WSL) at 1-4 pts. per acre. (Do not exceed 24 pts. per acre per season). 7-day PHI. RUP.

Foliar-applied products:

Actara® (25WDG) at 1.5-3 oz. per acre. Do not exceed 6 oz. per acre per season. See pollinator precautions. 14-day PHI.

Admire PRO® (4.6F) at 3.7 fl. oz. per acre. Do not exceed 5.6 fl. oz. per acre per season. See pollinator precautions. 7-day PHI.

Agri-Mek 0.15EC® at 8-16 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. 14-day PHI. RUP.

Ambush® (2EC) at 3.2-12.8 fl. oz. per acre. Do not exceed 1.6 lbs. a.i. per acre per season. 14-day PHI. RUP.

Asana XL® (0.66 EC) at 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. 7-day PHI. RUP.

Assail 30SG® at 1.5-4 oz. per acre. Do not exceed 4 applications per year. 7-day PHI.

Athena® at 7-17 fl. oz. per acre. 21-day PHI. RUP.

Avant 30WDG® at 3.5-6.0 oz. per acre. Do not exceed 24 oz. per acre per season. 7-day PHI.

Baythroid XL® (1EC) at 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. RUP.

Belay® (2.13SC) at 2-3 fl. oz. per acre. See pollinator precautions. 14-day PHI.

Blackhawk® at 1.7-3.3 oz. per acre. 7-day PHI.

Coragen® (1.67SC) at 3.5-5.0 fl. oz. per acre. Do not exceed 15.4 fl. oz per acre per season. 14-day PHI.

Endigo ZC® at 3.5-4.5 fl. oz. per acre. 14-day PHI. RUP.

Entrust® (2SC) at 3-10 fl. oz. per acre. Do not exceed 21 fl. oz. per acre per season. Observe resistance management restrictions. 7-day PHI.

Kryocide® (96D) at 10-12 lbs. per acre. Apply by air in 5-15 gals. of water per acre, or by ground in 25-100 gals. of water per acre at a minimum of 7-day intervals. Do not exceed 96 lbs. per acre per season. 0-day PHI.

Mustang Maxx® (0.8EC) at 3.2-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. RUP.

Novodor® at 1-3 qts. per acre. Small Colorado potato beetle larvae only. Bacillus thuringiensis-based insecticide. 0-day PHI.

Pounce 25WP® at 6.4-12.8 oz. per acre. Do not exceed 6.4 lbs. per acre per season. 14-day PHI. RUP.

Prokil Cryolite 50D® at 19-23 lbs. per acre. Do not exceed 184 lbs. per acre per season. 0-day PHI.

Radiant SC® at 4.5-8 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. 7-day PHI.

Rimon 0.83EC® at 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre. 14-day PHI.

This is a reduced-risk pesticide. See page 37 for details.

This is a biopesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.
Sevin XLR PLUS® (4F) at 1-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.

Sivanto® at 10.5-14 fl. oz. per acre.

Torac® (1.29EC) at 1-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.

Voliam Flexi® at 4 oz. per acre. 14-day PHI.

Warrior II® (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 2 applications per season. 14-day PHI. RUP.

**Cutworms**

**Recommended Products**

- Ambush® (2EC) at 3.2-12.8 oz. per acre. Do not exceed 1.6 lbs. a.i. per acre per season. 14-day PHI. RUP.
- Asana XL® (0.66 EC) at 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. 7-day PHI. RUP.
- Bacillus thuringiensis products (Biobit HP®, DiPel DF®, XenTari®, etc.) at 0.5-1 lb. per acre. 0-day PHI.
- Baythroid XL® (1EC) at 0.8-1.6 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. RUP.
- Endigo ZC® at 3.5-4.5 fl. oz. per acre. 14-day PHI. RUP.
- Lannate VL® (2.4WSL) at 1.5-3 pts. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. RUP.
- Mustang Maxx® (0.8EC) at 1.28-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. RUP.
- Pounce 25WP® at 6.4-12.8 fl. oz. per acre. 14-day PHI. RUP.
- Sevin XLR PLUS® (4F) at 1-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.
- Warrior II® (2.08EC) at 0.96-1.6 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 1-day PHI. RUP.

**European Corn Borers**

**European Corn Borer Threshold**

1 egg mass per 25 leaves

**Recommended Products**

- Ambush® (2EC) at 3.2-12.8 oz. per acre. Do not exceed 1.6 lbs. a.i. per acre per season. 14-day PHI. RUP.
- Asana XL® (0.66 EC) at 5.8-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. 7-day PHI. RUP.
- Assail® at 1.5-4 oz. per acre. Do not exceed 4 applications per year. 7-day PHI.
- Athena® at 7-17 fl. oz. per acre. 21-day PHI. RUP.
- Avaunt 30WDG® at 3.5-6.0 oz. per acre. Do not exceed 24 oz. per acre per season. 7-day PHI.
- Baythroid XL® (1EC) at 1.6-2.8 fl. oz. per acre. Do not exceed 6 applications or 16.8 fl. oz. per acre per season. 0-day PHI. RUP.
- Blackhawk® at 1.7-3.3 oz. per acre. 7-day PHI.
- Endigo ZC® at 4-4.5 fl. oz. per acre. 14-day PHI. RUP.
- Coragen® (1.67SC) at 3.5-5.0 fl. oz. per acre. Do not exceed 15.4 fl. oz per acre per season. 14-day PHI.
- Entrust® (2SC) at 3-10 fl. oz. per acre. Do not exceed 21 fl. oz. per acre per season. Observe resistance management restrictions. 7-day PHI.
- Mustang Maxx® (0.8EC) at 1.76-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 14-day PHI. RUP.
- Pyrene® at 1-12 fl. oz. per acre. 0-day PHI.
- Radiant SC® at 4.5-8 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. 7-day PHI.
- Rimon 0.83EC® at 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. per acre. 14-day PHI.
- Sevin XLR PLUS® (4F) at 1-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.
- Voliam Flexi® at 4 oz. per acre. 14-day PHI.
- Warrior II® (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. RUP.

**Flea Beetles**

**Flea Beetle Threshold**

2 per sweep

**Recommended Products**

- Cruiser 5FS® or Cruiser Maxx®. Rates vary according to seeding rate and row spacing. See labels. For best results, plant potatoes immediately after treatment.
- Endigo ZC® at 4-4.5 fl. oz. per acre. 14-day PHI. RUP.

**This is a reduced-risk pesticide. See page 37 for details.**

**May be acceptable for use in certified organic production. Check with your certifier before use.**
Potato - Insect Control

Lannate LV® (2.4WSL) at 1.5 pts. per acre. Do not exceed 15 pts. per acre per season. 6-day PHI. RUP.

Pyrenone® at 1-12 fl. oz. per acre. 0-day PHI.

Scorpion 35SL® at the following rates:
- Soil application: 11.5-13.25 fl. oz. per acre.
- Foliar application: 2-2.75 fl. oz. per acre.

Sevin XLR PLUS® (4F) at 0.5-1 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI. RUP.

Thimet 20G® at the following rates:
- Light or sandy soils: 8.5-11.3 oz. per 1,000 linear ft. of row for any spacing (minimum 32-inch spacing).
- Heavy or clay soils: 13.0-17.3 oz. per 1,000 linear ft. of row.

Apply as a band application on each side of row and beneath the soil surface or in the seed furrow. 90-day PHI. RUP.

Voliam Flex® at 4 oz. per acre. 14-day PHI.

Warrior II® (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. RUP.

Potato Leafhoppers

Recommended Products

Soil-applied or seed piece treatment materials:

Admire PRO® (4.6F) at 0.17-0.35 fl. oz. per 100 lbs of seed, or 5.7-8.7 fl. oz. per acre. Apply directly to seed piece or below seed piece at planting. Can expect 40-50 days of control. Do not exceed 0.31 lb. a.i. per acre per season. See pollinator precautions.

Belay® at 0.4-0.6 fl. oz. per 100 lbs. of seed, or 9-12 fl. oz per acre at planting. See label for application methods. 14-day PHI.

Cruiser 5FS® or Cruiser Maxx®. Rates vary according to seeding rate and row spacing. See labels. For best results, plant potatoes immediately after treatment. RUP.

Platinum 2SC** at 5-8 fl. oz. per acre, or Platinum Ridomil Gold® at 2.2 fl. oz. per 1,000 linear ft. of row. *Reduced-risk pesticide. Apply directly to seed piece in sufficient water to cover entire seed piece. Do not exceed 8 fl. oz. of Platinum 2SC®, or 38 fl. oz. of Platinum Ridomil Gold® per acre per season. Can expect 90-100 days control. See pollinator precautions.

Sivanto® at 7-10.5 fl. oz. per acre.

Scorpion 35SL® at 11.5-13.25 fl. oz. per acre as a soil application.

Thimet 20G® at the following rates:
- Light or sandy soils: 8.5-11.3 oz. per 1,000 linear ft. of row for any spacing (minimum 32-inch spacing).
- Heavy or clay soils: 13.0-17.3 oz. per 1,000 linear ft. of row.

Apply as a band application on each side of row and beneath the soil surface or in the seed furrow. 90-day PHI. RUP.

Foliar-applied materials:

Actara® (25WDG) at 1.5-3 oz. per acre. Do not exceed 6 oz. per acre per season. Control may require 2 applications at a 7-10 day interval. See pollinator precautions. 14-day PHI.

Admire Pro® (4.6F) at 1.3 fl. oz. per acre. Do not exceed 5.6 fl. oz. per acre per season. See pollinator precautions. 7-day PHI.

Ambush® (2EC) at 3.2-12.8 oz. per acre. Do not exceed 1.6 lbs. a.i. per acre per season. 14-day PHI.

Asana XL® (0.66 EC) at 2.9-9.6 fl. oz. per acre. Do not exceed 67.2 fl. oz. per acre per season. 7-day PHI. RUP.

Assail 30SG® at 1.5-4 oz. per acre. Do not exceed 4 applications per year. 7-day PHI.

Athena® at 7-17 fl. oz. per acre. 21-day PHI. RUP.

Baythroid XL® (1EC) at 0.8-1.6 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. RUP.

Belay® (2.13SC) at 2-3 fl. oz. per acre. See pollinator precautions. 14-day PHI.

Dimethoate 400® or Dimethoate 4E® at 0.5-1 pt. per acre, or Dimethoate 2.67EC® at 0.75-1.5 pts per acre.. 0-day PHI for Dimethoate 400® or Dimethoate 2.67EC®. 2-day PHI for Dimethoate 4E®.

Endigo ZC® at 4-4.5 fl. oz. per acre. 14-day PHI. RUP.

Lannate LV® (2.4WSL) at 1.5-3 pts. per acre. Do not exceed 15 pts. per acre per season. 6-day PHI. RUP.
Malathion® products at the following rates:

- **5**: 1 pt. per acre.
- **5EC**: 2 pts. per acre.
- **57EC**: 1-1.5 pts. per acre.

0-day PHI.

**Mustang Maxx®** (0.8EC) at 1.76-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. **RUP**.

**Pounce 25WP®** at 6.4-12.8 oz. per acre. Do not exceed 6.4 lbs. per acre per season. 14-day PHI. **RUP**.

**Pyrenone®** at 1-12 fl. oz. per acre. 0-day PHI.

**Scorpion 35SL®** at 2-2.75 fl. oz. per acre as a foliar application. 7-day PHI.

**Sevin XLR PLUS®** (4F) at 0.5-2 qts. per acre. Do not exceed 6 qts. per acre per crop. 7-day PHI.

**Sivanto®** (200SL) at 7-10.5 fl. oz. per acre. 7-day PHI.

**Torac®** (1.29EC) at 14-21 fl. oz. per acre. Do not exceed 2 applications per season. 14-day PHI.

**Transform WG®** at 1.5-2.25 oz. per acre. Do not apply more 8.5 oz. per acre per year. 7-day PHI.

**Voliam Flexi®** at 4 oz. per acre. 14-day PHI.

Vydate C-LV® at 17-34 fl. oz. per acre (do not exceed 198 fl. oz. per are per season), or **Vydate L®** (2WSL) at 2-4 pts. per acre (do not exceed 24 pts. per are per season). 7-day PHI. **RUP**.

**Warrior II®** (2.08EC) at 0.96-1.6 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. **RUP**.

### Recommended Products

**Admire PRO®** (4.6F) at 0.17-0.35 fl. oz. per 100 lbs of seed, or 5.7-8.7 fl. oz. per acre. Apply directly to seed piece or below seed piece at planting.

**Brigade** (2EC) at 9.6-19.2 fl. oz. per acre at planting. 21-day PHI. **RUP**.

**Capture LFR®** at 12.75-25.5 fl. oz. per acre at planting. **RUP**.

**Cruiser 5FS®** at 0.11-0.16 fl. oz. per 100 lbs of seed pieces. Rates vary according to seeding rate and row spacing. See labels.

**Diazinon®. Ohio only.** Ohio has 24c special local needs for this product on potato for wireworm suppression.

**Platinum®** (2SC) at 5-8 fl. oz. per acre. Apply to seed pieces. See pollinator precautions.

**Regent 4SC®** at 0.184-0.220 fl. oz. per 1000 row feet, applied in-furrow at-planting.

**Thimet 20G®** before or at time of planting at the following rates:

- **Light or sandy soils**: 8.5-11.3 oz. per 1,000 linear ft. of row for any spacing (minimum 32-inch spacing).
- **Heavy or clay soils**: 13.0-17.3 oz. per 1,000 linear ft. of row.

No effective treatment after planting. Treatment at planting may only provide 65% control. Apply as a band application on each side of row and beneath the soil surface, or in the seed furrow. 90-day PHI. **RUP**.

### Wireworms

- **Site selection**: wireworms are most likely to be a problem in fields recently planted to sod or pasture, or in fields that have had a grassy weed problem.

- **Sampling**: check for the presence of wireworms by burying a potato 6 inches deep in 5 locations per field prior to planting. Mark the spots with flags. Dig up the potatoes and inspect for wireworms 7 days later.
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.

Disease Control
Ascochyta Leaf Spot
Fertilize in fall for growth in the spring. Remove older, yellowed leaves or leaves with lesions in the fall.

Crown Rot
Use disease-free plants. Plant only on well-drained soil.

Weed Control
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 Table 25 on page 66.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

Dormant or Shielded Applications
Broadleaves and Grasses
Recommended Products
Gramoxone Inteon 2L® at 2.5-4 pts. per acre. Use 1 qt. of COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply in spring before buds begin to grow. Do not exceed 2 applications per season. RUP.

Glyphosate products at 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 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. 14-day PHI.
**Dormant or Shielded Applications Broadleaves**

**Recommended Products**

**Aim EC®** at 0.5-2 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.

**Callisto 4L®** at 6 fl. oz. per acre. Apply to dormant rhubarb. Use COC or NIS to improve control of emerged weeds. 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. 21-day PHI.

**Preemergence Broadleaves and Grasses**

**Recommended Products**

**Calisto 4SC®** at 6 fl. oz. per acre. Apply to soil before rhubarb breaks dormancy in the spring. Applying after growth begins will cause crop stunting and bleaching. 21-day PHI.

**Caporol 4L®** at 2-4 pts. per acre. Apply to dormant rhubarb before leaves emerge in spring. Use low rate on light soils. 40-day PHI.

**Casoron 4G®** at 50 lbs. per acre. Apply before rhubarb emerges in early spring. Must be watered into soil.

**Command 3ME®** at 4 pts. per acre. Apply to dormant rhubarb before leaves emerge.

**Dual Magnum 7.62E®** at 0.67-1.33 pts. per acre. Apply in spring before rhubarb and weeds emerge. Make a second application after harvest. Do not exceed 1.33 pts. per acre per year. 62-day PHI.

**Kerb 3.3 SC®** at 2.5-5 pts. per acre. 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. *Growers in Michigan should be in possession of the 24(c) label. RUP.*

**Lorox 50DF®** at 2-3 lbs. per acre. Apply broadcast to dormant rhubarb in the spring before leaves emerge.

**Sandea 75DF®** at 0.5-1 oz. per acre. *Not for yellow nutsedge or grasses.* Apply to dormant rhubarb in the spring. May cause crop stunting. Use low rate to determine crop safety under field conditions.

**Postemergence Broadleaves**

**Recommended Products**

**Quinstar 4L®** at 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. 30-day PHI.

**Postemergence Grasses**

**Recommended Products**

**Clethodim products at the following rates:**

**Select Max®** at 9-16 fl. oz. per acre. Use Select Max® with 8 fl. oz. of NIS per 25 gals. of spray solution (0.25% v/v). Do not exceed 64 fl. oz. of Select Max® per acre per season.

**2EC formulations of clethodim products** at 6-8 fl. oz. per acre. Use 2EC formulations 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.

Spray on actively growing grass. Wait at least 14 days between applications. 30-day PHI.

**Poast 1.5E®** at 1-1.5 per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 3 pts. per acre per season. 15-day PHI for Illinois, Indiana, and Minnesota. 30-day PHI for other states.

**Insect Control**

**Aphids, Leafhoppers, Whiteflies**

**Recommended Products**

**Actara® (25WDG)** at the following rates:

*Aphids or leafhoppers*: 1.5-3.0 oz. per acre.

*Whiteflies*: 3.0-5.5 oz. per acre.

Do not exceed 11 oz. per acre per season. 7-day PHI.

**Admire PRO® (4.6F)** applied to the soil at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 lb. a.i. per acre per season. 45-day PHI.

**Assail® (30SG)** at 2-4 oz. per acre. Do not exceed 5 applications per season. 7-day PHI.

**Belay® (2.13 SC)** at 3-4 fl. oz. per acre. 7-day PHI.

**Beleaf® (50SG)** at 2-2.8 oz. per acre. *Aphids only*. 0-day PHI.

This is a reduced-risk pesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.
Brigade® (2EC) at 2.1-6.4 fl. oz. per acre (do not exceed 32 fl. oz. per acre per season), or Brigade® (WSB) at 5.3-16.0 oz. per acre (do not exceed 80 oz. per acre per season). 7-day PHI. RUP.

Fulfill® (50WDG) at 2.75 oz. per acre. Do not exceed 5.5 oz. per acre per season. 7-day PHI.

Mustang Maxx® (0.8EC) at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. RUP.

Platinum® (2SC) at 5-11 fl. oz. per acre. Do not exceed 1 fl. oz. per acre per season. 30-day PHI.

Pounce 25W® at 6.4-12.8 oz. per acre. Do not exceed 4 lbs. per acre per season. 1-day PHI. RUP.

Sivanto® (200SL) at 10.5-12 fl. oz. per acre. 1-day PHI.

**Armyworms, Corn Earworms,**

**Cutworms, Loopers**

**Recommended Products**

Ambush® (2EC) at 6.4-12.8 fl. oz. per acre. 1-day PHI.

Baythroid XL® (1EC) at 0.8-3.2 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 0-day PHI.

Brigade® (2EC) at 2.1-6.4 fl. oz. per acre (do not exceed 32 fl. oz. per acre per season), or Brigade® (WSB) at 5.3-16.0 oz. per acre (do not exceed 80 oz. per acre per season). 7-day PHI. RUP.

Coragen® (1.67SC) at 3.5-5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. 1-day PHI.

Entrust® (2SC) at 4-8 fl. oz. per acre. Armyworms and loopers only. Do not exceed 29 fl. oz. per acre per season. Observe resistance management restrictions. 1-day PHI.

Intrepid 2F® at 4-10 fl oz. per acre. Armyworms and loopers only. Do not exceed 64 fl. oz. per acre. 1-day PHI.

Larvin 3.2L® at 16-30 fl. oz. per acre. Not for cutworms. Do not exceed 60 fl. oz. per acre per season. 14-day PHI. RUP.

Mustang Maxx® (0.8EC) at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. RUP.

Pounce 25W® at 6.4-12.8 oz. per acre. Also for European corn borers. Do not exceed 4 lbs. per acre per season. 1-day PHI. RUP.

Radiant SC® at 5-10 fl. oz. per acre. Not for cutworms. Do not exceed 34 fl. oz. per acre per season. 1-day PHI.

Sevin XLRPlus® at 1-2 qts. per acre. Do not exceed 6 qts. per acre per season. 14-day PHI.

**Common Stalk Borers, Rhubarb Curculios**

There are no registered insecticides that will give adequate control.

Control by cultivating field and margins. Remove curly dock, the normal host of rhubarb curculios.

**Rhubarb - Insect Control**

This is a reduced-risk pesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.
Root Crops

Beet, Carrot, Parsnip, Radish, Rutabaga, and Turnip

<table>
<thead>
<tr>
<th>Varieties</th>
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<tbody>
<tr>
<td><strong>Beets</strong></td>
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<tr>
<td><strong>Carrots</strong></td>
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<tr>
<td><strong>Parsnips</strong></td>
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<tr>
<td><strong>Radishes</strong></td>
</tr>
<tr>
<td><strong>Turnips</strong></td>
</tr>
</tbody>
</table>

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. P₂O₅: 20 to 160 pounds per acre. K₂O: 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.

Disease Control

**Alternaria Leaf Blight (Late Blight) (carrot, parsnip, radish, turnip), Cercospora Leaf Spot (Early Blight) (carrot, beet, parsnip, turnip)**

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 (page 77) for details.

**Recommended Products**

Bravo®, Echo®, Equus®, and Initiate® are labeled for use at various rates. 0-day PHI for carrot. 10-day PHI for parsnip.

**Cabrio EG** at 8–12 oz. per acre. 0-day PHI.

Several copper products are available at various rates. Not all crops are listed on all copper product labels. Cercospora only.

**Endura 70WG** at 4.5 oz. acre. Alternaria on carrot only. 0-day PHI.

**Flint** at the following rates:

Carrot, beet, parsnip, turnip: 2-3 oz. per acre.

Alternaria on radish only: 2-4 oz. per acre.

7-day PHI.
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.

**Recommended Product**

Copper products labeled for Cercospora may provide some control.

**Cavity Spot (carrot)**

Cavity spot can affect root quality and yield.

**Recommended Products**

- **Presidio** at 4 fl. oz. per acre in-furrow at 5-10 gals. per acre. 7-day PHI.
- **Ranman** at 6 fl. oz. per acre. 14-day PHI.
- **Reason 500SC** at 8.2 fl. oz. per acre. 14-day PHI.
- **Ridomil Gold SL** at the following rates:
  - Preplant incorporation or soil spray: 0.5-1.3 pts. per acre.
  - Postplant chemigation, shank-in, or directed spray: 0.25-1 pt. per acre.
- **Ridomil Gold Copper** at 2 lbs. per acre as a foliar spray. 7-day PHI.
- **Ultra Flourish** at the following rates:
  - Preplant incorporation or soil spray: 0.5-2 pts. per acre.
  - Postplant chemigation, shank-in, or directed spray: 0.5-2 pts. per acre.

**Damping-off (beet, parsnip, radish, turnip)**

Conditions that favor rapid seedling germination may limit damping-off severity. Avoid excessive irrigation and poorly drained soils.

**Recommended Products**

- **Presidio** at 3-4 fl. oz. per acre. Pythium damping-off only. 0-day PHI.
- **Quadris Flowable 2.08SC** at 0.4-0.8 fl. oz. per 1,000 row-feet. 0-day PHI.
- **Reason 500SC** at 8.2 fl. oz. per acre. Pythium damping-off only. 14-day PHI.

This is a reduced-risk pesticide. See page 37 for details.
**Downy Mildew, White Rust (radish, turnip)**
Practice a 3-year crop rotation. Plow crop residue as soon as possible after harvest. Avoid volunteer plants and cruciferous weeds.

**Recommended Products**
- **Cabrio EG®** at 8-16 oz. per acre. *White rust only.* 0-day PHI.
- **Ridomil Gold Copper®** at 2 lbs. per acre as a foliar spray. *Radish only.* 7-day PHI.

**Root Knot Nematode**
Sample fields for plant parasitic nematodes before planting. Avoid fields with high numbers of root-knot nematodes.

**Septoria Leaf Spot (radish)**
Practice a 3-year crop rotation. Plow crop residue as soon as possible after harvest. Avoid volunteer plants and cruciferous weeds.

**Recommended Products**
- **Flint®** at 2-4 oz. per acre. 7-day PHI.

**White Mold (carrot)**
Practice a 3-4-year crop rotation. Avoid rotating with beans, cucurbits, celery, and late cabbage.

**Recommended Products**
- **Endura 70WG®** at 7.8 oz. acre. *Carrot only.* 0-day PHI.
- **Fontelis 1.67SC®** at 16-30 fl. oz. per acre. 0-day PHI.

**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 speeded 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 Table 25 on page 66.

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 Applications**

**Broadleaves and Grasses**

**Recommended Products**
- **Glyphosate** products at 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. 14-day PHI.
- **Gramoxone Inteon 2L®** at 2-4 pts. per acre. *Carrots and turnips only.* Not for beets, horseradish, parsnips, or radishes. 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. RUP.

**Preemergence Broadleaves and Grasses**

**Recommended Products**
- **Dual Magnum®** at the following rates:
  - **Carrots in Indiana, Minnesota, Michigan, and Ohio only.** 0.67-1.3 pts. per acre on mineral soils, or 1.3-2 pts. per acre on muck soils (less than 20% organic matter). Apply postemergence after carrots have 3-5 true leaves. 64-day PHI.
  - **Beet, radish, and turnip root in Indiana, Michigan and Ohio only; parsnip in Michigan only.** 0.67-1 pt. per acre. 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 pt. per acre per crop or 1 application per crop.**
Lorox 50DF® at the following rates:

*Carrots in Michigan and Minnesota only*: 1-2 lbs. per acre.

*Parsnips*: 1.5-3 lbs. per acre.

Do not use on sand, loamy sand, or soils with less than 1% organic matter. Apply after seeding before crop emerges. Plant seed at least 1/2 inch deep. Do not use on other root crops.

Nortron SC® at the following rates:

*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.

*Beets only*. May cause temporary leaf fusion. May injure stressed plants. Use on mineral soils only. Do not exceed 96 fl. oz. per acre per season.

Outlook® at 12-21 fl. oz. per acre. *Horseradish only.* Apply from 2-leaf stage to 8-leaf stage of horseradish. Cold, wet conditions at application may stunt horseradish. Will not control emerged weeds.

Prowl H2O® at 2 pts. per acre. *Carrots only.* 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. 60-day PHI.

Trifluralin products at 0.5-0.75 lb. a.i. per acre. Use 4EC formulations at 1-1.5 pts. per acre. *Carrots and radishes only.* Use lowest rate on coarse soils. Apply and incorporate before planting. Not effective on soils with high organic matter.

**Preemergence Broadleaves**

**Recommended Products**

Goal 2XL® at 2 pts. per acre. *Horseradish only.* Apply after planting prior to crop emergence.

Spartan 75DF®, at 1.5-5.3 oz. per acre, or Spartan 4F®, at 2.25-8.0 fl. oz. per acre, or Spartan Charge® at 2.9-10.2 fl. oz. per acre. *Horseradish only.* 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 sand soils with less than 1% organic matter. Do not exceed 5.3 oz. of Spartan 75DF® per 12-month period. 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.

Pyramin 4.5SC® at 2.75-3.25 qts. per acre, or Pyramin 65DF® at 4.6-5.4 lbs. per acre. Beets only. Apply after seeding before crop emerges, or use high rate after beets have 2 expanded true leaves and before weeds have more than 2 leaves. Rainfall or irrigation necessary for effective control of nonemerged weeds. Do not apply if beets are stressed or injured. Do not use preemergence on muck soils; do not use at all on sands or sandy loam soils. Do not exceed 6.5 qts. of Pyramin 4.5SC® or 11.25 lbs. of Pyramin DF® per acre.

Postemergence Broadleaves

Recommended Products

Aim EC® at 0.5-2 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.

Pyramin 4.5SC® See details above for Preemergence Broadleaves.
# Herbicides for Root Crops: Beet, Carrot, Horseradish, Radish and Turnip

<table>
<thead>
<tr>
<th>Products (REI/PHI)</th>
<th>Common Name</th>
<th>Timing and Application Location Relative to Crop</th>
<th>Incorporated</th>
<th>Timing Relative to Weeds</th>
<th>Weed Groups Controlled</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before seeding/planting</td>
<td>Post emergence-before emergence</td>
<td>Post-emergence-between rows only</td>
<td>Postemergence</td>
<td>Preemergence</td>
</tr>
<tr>
<td>Aim EC’ (12h)</td>
<td>carfentrazone</td>
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<tr>
<td>Dual Magnum’ (24/variable)</td>
<td>s-metolachlor</td>
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<td>oxyfluorfen</td>
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<tr>
<td>Gramoxone Inteon 2L’ (12h to 24h)</td>
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<tr>
<td>Lorox 50DF’ (24h/14d)</td>
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<tr>
<td>Nortron SC’ (12h/-)</td>
<td>ethofumesate</td>
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<tr>
<td>Outlook’ (12h/5-)</td>
<td>dimethenamid-P</td>
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<td>Poast’ (12h/14d to 60d)</td>
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<td>Pyramin’ (12h/-)</td>
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<td>Ro-Neet’ (12h/-)</td>
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<td>Roundup’, others (12h/14d)</td>
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<td>Select Max’, others (12h/15d to 30 d)</td>
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<td>Sencor’ (12h/60d)</td>
<td>metribuzin</td>
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<td>Spartan’ (12h/-)</td>
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<td>Stinger’ (12h/30d)</td>
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<td>Treflan’, others (12h/-)</td>
<td>trifluralin</td>
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</tbody>
</table>

1 For effectiveness against specific weeds, see Table 25 on page 66, 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.

3 X=may be used for that crop; check label for application methods permitted.
Insect Control for Beets

**Aphids**

**Recommended Products**

- **Actara**® (25WDG) at 1.5-3 oz. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.
- **Admire PRO**® (4.6F) at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 lb. a.i. or 1 application per season. 21-day PHI.
- **Beleaf**® (50SG) at 2-2.8 oz. per acre. 3-day PHI.
- **Malathion 5EC**® at 1.5-2 pts. per acre. Do not exceed 3 applications per season. 7-day PHI.
- **M-Pede**® at 1-2% by volume. Must contact aphids to be effective. 0-day PHI.
- **Platinum**® (2SC) at 5-12 fl. oz. per acre. Do not exceed 12 fl. oz. per acre per season. Apply at planting. 0-day PHI.
- **Sivanto® (200SL)** at 7-10.5 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. 7-day PHI.

**Cutworms**

**Cutworm Threshold**

25% of plants infested

**Recommended Products**

- **Asana XL**® (0.66EC) at 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. 7-day PHI. **RUP.**
- **Baythroid XL**® (1EC) at 1.6-2.8 fl. oz. per acre. Do not exceed 14.0 fl. oz. per acre per season. 0-day PHI. **RUP.**
- **Brigade**® (2EC) at 5.1-6.4 fl. oz. per acre (do not exceed 32 fl. oz. per acre per season), or **Brigade**® (WSB) at 5.3-16.0 oz. per acre (do not exceed 80 oz. per acre per season). 21-day PHI. **RUP.**
- **Diazinon 50W**® at 4-8 lbs. per acre, or **Diazinon AG500**® at 2-4 qts. per acre. Broadcast just before planting and immediately incorporate into the soil. Do not exceed 5 applications per season. 14-day PHI. **RUP.**
- **Lannate LV**® (2.4WSL) at 1.5 pts. per acre. Do not exceed 10 applications or 21 pts. per acre per crop. 1-day PHI. **RUP.**
- **Mustang Maxx**® (0.8EC) at 1.28-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. **RUP.**
- **Sevin XLR PLUS**® (4F) at 1-2 qts. per acre. Do not exceed 6 qts. per acre per season. 7-day PHI.

**Variegated Cutworms**

**Recommended Products**

- **Asana XL**® (0.66 EC) at 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. 7-day PHI. **RUP.**
- **Baythroid XL**® (1EC) at 1.6-2.8 fl. oz. per acre. Do not exceed 14.0 fl. oz. per acre per season. 0-day PHI. **RUP.**
- **Brigade**® (2EC) at 5.1-6.4 fl. oz. per acre (do not exceed 32 fl. oz. per acre per season), or **Brigade**® (WSB) at 5.3-16.0 oz. per acre (do not exceed 80 oz. per acre per season). 21-day PHI. **RUP.**
- **Diazinon 50W**® at 4-8 lbs. per acre, or **Diazinon AG500**® at 2-4 qts. per acre. Broadcast just before planting and immediately incorporate into the soil. Do not exceed 5 applications per season. 14-day PHI. **RUP.**
- **Lannate LV**® (2.4WSL) at 1.5 pts. per acre. Do not exceed 10 applications or 21 pts. per acre per crop. 1-day PHI. **RUP.**
- **Mustang Maxx**® (0.8EC) at 1.28-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. **RUP.**
- **Sevin XLR PLUS**® (4F) at 1-2 qts. per acre. Do not exceed 6 qts. per acre per season. 7-day PHI.

**Leafhoppers**

**Leafhopper Threshold**

For susceptible varieties: 20 leafhoppers per 100 sweeps

**Recommended Products**

- **Actara**® (25WDG) at 1.5-3.0 oz. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.
- **Admire PRO**® (4.6F) at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 lb. a.i. or 1 application per season. 21-day PHI.
- **Beleaf**® (50SG) at 2-2.8 oz. per acre. 3-day PHI.
- **M-Pede**® at 1-2% by volume. Must contact aphids to be effective. 0-day PHI.
- **Platinum**® (2SC) at 5-12 fl. oz. per acre. Do not exceed 12 fl. oz. per acre per season. Apply at planting. 0-day PHI.
- **Sivanto® (200SL)** at 7-10.5 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. 7-day PHI.

**Leafhoppers**

Plant resistant varieties. Use varieties resistant to aster yellows.

**Leafhopper Threshold**

For susceptible varieties: 20 leafhoppers per 100 sweeps

**Recommended Products**

- **Actara**® (25WDG) at 1.5-3.0 oz. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.
- **Admire PRO**® (4.6F) at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 lb. a.i. or 1 application per season. 21-day PHI.
- **Asana XL**® (0.66 EC) at 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. 7-day PHI. **RUP.**
- **Baythroid XL**® (1EC) at 1.6-2.8 fl. oz. per acre. Do not exceed 14.0 fl. oz. per acre per season. 0-day PHI. **RUP.**
- **Lannate LV**® (2.4WSL) at 1.5 pts. per acre. Do not exceed 10 applications or 21 pts. per acre per crop. 1-day PHI. **RUP.**
- **Platinum**® (2SC) at 5-12 fl. oz. per acre. Do not exceed 12 fl. oz. per acre per season. Apply at planting. 0-day PHI.

**Root Crops - Insect Control**

This is a reduced-risk pesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.
Sevin XLR PLUS® (4F) at 0.5-1 qt. per acre. Do not exceed 6 qts. per acre per season. 7-day PHI.

Sivanto® (200SL) at 7-10.5 fl. oz. per acre. 7-day PHI.

**Insect Control for Radishes**

**Aphids, Flea Beetles**

**Recommended Products**

- **Actara®** (25WDG) at 1.5-3 oz. per acre. Do not exceed 4 oz. per acre per season. 7-day PHI.

- **Admire PRO®** (4.6F) at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 a.i. or 1 application per season. 21-day PHI.

- **Asana XL®** (0.66 EC) at 5.8-9.6 oz. per acre. *Flea beetles only*. Do not exceed 19.2 fl. oz. per acre per season. 0-day PHI. RUP.

- **Beleaf®** (50SG) at 2-2.8 oz. per acre. *Aphids only*. 3-day PHI.

- **Brigade®** (2EC) at 2.1-6.4 fl. oz. per acre (do not exceed 32 fl. oz. per acre per season), or **Brigade®** (WSB) at 5.3-16.0 oz. per acre (do not exceed 80 oz. per acre per season). 21-day PHI. RUP.

- **Malathion 5EC®** at 1.5 pts. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.

- **M-Pede®** at 1-2% by volume. *Aphids only*. Must contact aphids to be effective. 0-day PHI.

- **Platinum®** (2SC) at 5-6.5 fl. oz. per acre. Do not exceed 12 fl. oz. per acre per season. Apply at planting.

- **Sevin XLR PLUS®** (4F) at 0.5-1 qt. per acre. *Flea beetles only*. Do not exceed 6 qts. per acre per season. 7-day PHI.

- **Sivanto®** (200SL) at 7-10.5 fl. oz. per acre. 7-day PHI.

**Cutworms**

**Recommended Products**

- **Baythroid XL®** (1EC) at 1.6-2.8 fl. oz. per acre. Do not exceed 14.0 fl. oz. per acre per season. 0-day PHI. RUP.

**Root Maggots**

**Recommended Products**

- **Diazinon 50W®** at 4-6 lbs. per acre at planting, or **Diazinon AG600®** at 51-102 fl. oz. per acre at planting.

- **Lorsban 15G®** at 4.6-9.2 oz. per 1,000 linear ft. of row at planting, or **Lorsban 4E/Advanced®** at 1.6-3.3 fl. oz. per 1,000 linear ft. of row at planting.

**Aphids, Flea Beetles**

**Recommended Products**

- **Actara®** (25WDG) at 1.5-3 oz. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.

- **Admire PRO®** (4.6F) at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 lb. a.i. or 1 application per season. 21-day PHI.

- **Beleaf®** (50SG) at 2-2.8 oz. per acre. *Aphids only*. 3-day PHI.

- **Malathion 5EC®** at 1.5 pts. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.

- **M-Pede®** at 1-2% by volume. *Aphids only*. Must contact aphids to be effective. 0-day PHI.

This is a reduced-risk pesticide. See page 37 for details.

This is a biopesticide. See page 37 for details.

May be acceptable for use in certified organic production. Check with your certifier before use.
Platinum® (2SC) at 5-12 fl. oz. per acre. Apply at planting.

Sivanto® (200SL) at 7-10.5 fl. oz. per acre. 7-day PHI.

**Imported Cabbageworms, Armyworms**

**Recommended Products**

Several *Bacillus thuringiensis* products (Agree®, Biobit®, Dipel®, Javelin®, Xentari®) are available. Follow label directions. Begin applications when worms are small. Using *Bt* products will help conserve beneficial insects. 0-day PHI.

Brigade® (2EC) at 2.1-6.4 fl. oz. per acre (Do not exceed 32 fl. oz. per acre per season), or Brigade® (WSB) at 5.3-16.0 oz. per acre (do not exceed 80 oz. per acre per season). 21-day PHI.

Coragen® (1.67SC) at 3.5-5.0 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. 1-day PHI.

Mustang Maxx® (0.8EC) at 1.28-4 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 1-day PHI. *RUP.*

Radiant® (1SC) at 6-8 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 3-day PHI.

Sevin XLR PLUS® (4F) at 1-2 qts. per acre. Do not exceed 6 qts. per acre per season. 7-day PHI.

**Insect Control for Turnips**

**Aphids, Flea Beetles**

**Recommended Products**

Actara® (25WDG) at 1.5-3 oz. per acre. Do not exceed 8 oz. per acre per season. 7-day PHI.

Admire PRO® (4.6F) at 4.4-10.5 fl. oz. per acre. Do not exceed 0.38 lb. a.i. or 1 application per season. 21-day PHI.

Ambush 25W® at 3.2-6.4 fl. oz. per acre. *Aphids in Illinois and Indiana only.* Do not exceed 8 applications per season. 1-day PHI. *RUP.*

Asana XL® (0.66 EC) at 5.8-9.6 oz. per acre. *Flea beetles only.* Do not exceed 76.8 fl. oz. per acre. 7-day PHI. *RUP.*

Beleaf® (2EC) at 2.1-6.4 fl. oz. per acre,
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

<table>
<thead>
<tr>
<th>Corn Type or Brand</th>
<th>Isolate from these Types or Brands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard (su)</td>
<td>Shrunken-2, Xtra Tender, Gourmet Sweet</td>
</tr>
<tr>
<td>Sugar-enhanced (se)</td>
<td>Shrunken-2, Xtra Tender, Gourmet Sweet</td>
</tr>
<tr>
<td>TripleSweet, Synergistic</td>
<td>Shrunken-2, Xtra Tender, Gourmet Sweet</td>
</tr>
<tr>
<td>Shrunken-2 (sh2)</td>
<td>Standard, Sugar-enhanced, TripleSweet, Synergistic</td>
</tr>
<tr>
<td>Xtra Tender, Gourmet Sweet</td>
<td>Standard, Sugar-enhanced, TripleSweet, Synergistic</td>
</tr>
</tbody>
</table>

¹Isolate 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. P₂O₅: 0 to 100 pounds per acre. K₂O: 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 + K₂O 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).

Disease Control

**Anthracnose**

**Recommended Products**

*Headline*® at 6-12 fl. oz. per acre. 7-day PHI.

*Priaxor*® at 4-8 fl. oz. per acre. 7-day PHI.

*Quadris Flowable*® at 6.2-15.5 fl. oz. per acre. 7-day PHI.

*Quilt*® at 10.5-14 fl. oz. per acre. 14-day PHI.

*Quilt Xcel*® at 10.5-14 fl. oz. per acre. 14-day PHI.

**“Helminthosporium” Leaf Blight, Southern Corn Leaf Blight, Northern Corn Leaf Blight, Northern Corn Leaf Spot**

Plant resistant varieties. For an up-to-date list of sweet corn hybrid reactions to prevalent diseases, visit the University of Illinois’ Sweet Corn Disease Nursery website, www.sweetcorn.uiuc.edu. Or refer to the Purdue Extension bulletin, *Midwest Vegetable Trial Report*, available from The Education Store at www.edustore.purdue.edu.

**Recommended Products**

*Bravo*, *Echo*, and *Equus*® are labeled for use at various rates. 14-day PHI.

*Headline*® at 6-12 fl. oz. per acre. 7-day PHI.

*Dithane*, *Manzate*, and *Penncozeb*® are labeled for use at various rates. 7-day PHI.

*Monsoon 3.6F*®, *Toledo 3.6F*®, or *Onset 3.6F*® at 4-6 fl. oz. per acre. 7-day PHI.

*Priaxor*® at 4-8 fl. oz. per acre. 7-day PHI.

*Propimax EC*® at 4 fl. oz. per acre. 14-day PHI.

*Quadris Flowable*® at 6.2-9.2 fl. oz. per acre. 7-day PHI.

*Quilt*® at 10.5-14 fl. oz. per acre. 14-day PHI.

*Quilt Xcel*® at 10.5-14 fl. oz. per acre. 14-day PHI.

*Tilt*® at 4 fl. oz. per acre. 14-day PHI.

**Smut**

Some hybrids tend to have fewer smut infections. Use past experience to choose successful hybrids. Avoid mechanical damage to corn plants. Try to avoid plant stresses that affect pollen production and silk emergence.

**Stewart’s Wilt**

Plant wilt-resistant hybrids — see the University of Illinois’ Sweet Corn Disease Nursery website, www.sweetcorn.uiuc.edu, or the Purdue Extension bulletin *Midwest Vegetable Trial Report*, available from The Education Store at www.edustore.purdue.edu.

Use an insecticide or seed treatment to control flea beetles. Insecticide treatments are more likely to be necessary in seasons following a mild winter.
**Virus Diseases** *(maize dwarf mosaic, chlorotic dwarf, wheat streak mosaic)*

Plant resistant or tolerant varieties — see the University of Illinois' Sweet Corn Disease Nursery website, www.sweetcorn.uiuc.edu, or the Purdue Extension bulletin *Midwest Vegetable Trial Report*, available from The Education Store at www.edustore.purdue.edu.

Control Johnsongrass and volunteer wheat.

**Weed Control**

For specific weeds controlled by each herbicide, check Table 25 on page 66.

Rates provided in the recommendations below are given for overall coverage. For band treatment, reduce amounts according to the portion of acre treated.

**Atrazine Restrictions**

Many herbicides labeled for corn contain atrazine. Observe the following restrictions on atrazine from all sources:

1. On highly erodible soils with low residue, do not apply more than 1.6 lbs. a.i. atrazine per acre before corn emerges.

2. On all soils, do not apply more than 2 lbs. a.i. atrazine per acre in one application.

3. On all soils, do not apply more than 2.5 lbs. a.i. atrazine per acre per year.

4. Check [www.atrazine-watershed.info](http://www.atrazine-watershed.info) or call (800) 365-3014 for additional local restrictions on the use of any material containing atrazine.

5. Water-quality setbacks. See labels for detailed information. Do not apply within 66 feet of the points where field surface water runoff enters perennial or intermittent streams and rivers, or within 200 feet around natural or impounded lakes and reservoirs. On highly erodible slopes, the 66 foot buffer must be seeded to a crop or grasses to provide cover. On tile-outletted terraced fields, one of the following must be done: (1) do not apply within 66 feet of standpipes, (2) no setback buffer around tile inlets, but immediately incorporate it to a depth of 2-3 inches in the entire field, or (3) no setback buffer around tile inlets, but maintain high crop surface residue such as in no-till systems.

**Burndown or Directed/Shielded Applications Broadleaves and Grasses**

**Recommended Products**

**Gramoxone Inteon 2L**® at 2-4 pts. per acre. Use 1 qt. COC or 4-8 fl. oz. of NIS per 25 gals. of spray solution. Apply before or after seeding but before crop emerges. Or use 1-2 pts. of Gramoxone Inteon 2L* and apply between rows using hooded or shielded sprayers, 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. **RUP.**

**Glyphosate** products at 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 or after seeding but before crop emerges; or after corn is 12 inches tall, apply up to 0.75 lb. ae between crop rows with hooded sprayers. Use low rate for annuals and higher rates for perennials. See label for suggested application volume and adjuvants. **7-day PHI.**

**Preemergence Broadleaves and Grasses**

**Recommended Products**

**Acetochlor** products including:

- **Breakfree 6.4EC**® at 1.5-3.75 pts. per acre.
- **Degree 3.8ME**® at 2.75-5.5 qts. per acre.
- **Harness 7EC**® at 1.5-3.0 pts. per acre.
- **Surpass 6.4EC**® at 1.5-3.75 pts. per acre.
- **TopNotch**® at 2-3 qts. per acre.
- **Breakfree ATZ**® (acetochlor + atrazine 3.0 + 2.25 ai) at 2.2-3.4 qts. per acre.
- **Breakfree ATZ Lite**® (acetochlor+atrazine 4.0 + 1.5 ai) at 1.6-3.0 qts. per acre.
- **Degree Xtra**® (acetochlor + atrazine 2.7 + 1.34 ai) at 2.9-3.7 qts. per acre.
- **FullTime**® (acetochlor + atrazine 2.4 + 1.6 ai) at 2.5-5.0 qts. per acre.
- **Harness Xtra 5.6L**® (acetochlor + atrazine 3.1 + 2.5 ai) at 1.4-3 qts. per acre.
- **Harness Xtra**® (acetochlor + atrazine 4.3 +1.7 ai) at 1.8-3.3 qts. per acre.
- **Keystone**® (acetochlor + atrazine 3.0 + 2.25 ai) at 2.2-3.4 qts. per acre, or **Keystone LA**® (acetochlor + atrazine 4.0 + 1.5 ai) at 1.6-3.0 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. **RUP.**

**Acuron 3.34SC**® at the following rates:

- **Soils with <3% organic matter:** 2.5 qts. per acre.
- **Soils with ≥ 3% organic matter:** 3.0 qts. per acre.

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. 45-day PHI for grazing and forage. RUP.

Alachlor products containing 4 lbs. a.i. per gal. at 2-3.25 qts. per acre. Use lower rates on coarse soils with low organic matter. Apply before planting and incorporate, or apply after planting before corn emerges. May be mixed with atrazine, see label for details. RUP.

Atrazine products at 1-2 lbs. active ingredient (a.i.) per acre. Use 4L formulations at 1-2 qts. per acre, or 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 3 qts. of Lexar® or LexarEZ® per acre per year. Do not exceed 3 qts. of Lumax® per acre per year. Do not exceed 3.25 qts. of LumaxEZ® per acre per year. 60-day PHI. RUP.

Atrazine products at 1-2 lbs. active ingredient (a.i.) per acre. Use 4L formulations at 1-2 qts. per acre, or 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 lbs. a.i. per acre before corn emerges on highly erodable soils with low residue; do not exceed 2.5 lbs. a.i. total per acre per year. RUP.

Anthem ATZ® for processing and fresh market sweet corn at the following rates:

Soils with <3% organic matter: 1.75-3 pts. per acre depending on soil texture (check label).

Soils with >3% organic matter: 1.75-4 pts. per acre depending on soil texture (check label).

For control of many broadleaf and grass weeds. Do not make more than 1 application to spring corn. See label for crop rotation intervals. 45-day PHI.

Anthem Maxx® for processing and fresh market sweet corn at the following rates:

Soils with <3% organic matter: 3.5-5.5 fl. oz. per acre depending on soil texture (check label).

Soils with >3% organic matter: 3.5-6.5 fl. oz. per acre depending on soil texture (check label).

For control of many broadleaf and grass weeds. Do not make more than 1 application to spring corn. See label for crop rotation intervals. 40-day PHI.

Define 60DF® at 12-21 oz. per acre, or Define SC® at 15-25 fl. oz. 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 tank-mixed with atrazine or simazine. See labels for details.

Dimethenamid-P (1.7 lbs. a.i. per gallon) plus atrazine (3.3 lbs. a.i. per gallon) products at 2.5-4.6 pts. per acre — including the following: Guardsman Max®, Commit ATZ®, and Establish ATZ®. Or Dimethenamid-P (2.25 lbs. a.i. per gallon) plus atrazine (2.75 lbs. a.i. per gallon) products at 2.0 to 3.5 pts. per acre — including the following: G-Max Lite®, Commit ATZ Lite®, and Establish ATZ Lite®. 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. 50-day PHI. RUP.

Lexar® or Lexar EZ® at 3 or 3.5 qts. per acre; or Lumax® at 2.5 or 3 qts. per acre; or Lumax EZ® at 2.7 or 3.25 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. Lexar® and LexarEZ® contain 1.74 lbs. s-metolachlor, 0.22 lb. mesotrione and 1.74 lb. atrazine per gallon. Lumax® contains 2.68 lbs. s-metolachlor, 0.268 lb. mesotrione and 1 lb. atrazine per gallon. LumaxEZ® contains 2.49 lbs. s-metolachlor, 0.249 lb. mesotrione, and 0.94 lb. atrazine per gallon. 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® or LexarEZ® per acre per year. Do not exceed 3 qts. of Lumax® per acre per year. Do not exceed 3.25 qts. of LumaxEZ® per acre per year. 60-day PHI. RUP.

Outlook® at 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. 50-day PHI.

Prowl H2O® at 2-4 pts. per acre. Use low rates on coarse soils with low organic matter. Apply after planting before corn emerges, or after emergence until corn is 20-24 inches 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 pre- and postemergence.

s-metolachlor products containing 7.6 lbs. a.i. per gal. at 1-2 pts. per acre — including the following: Brawl®, Brawl II®, Dual Magnum®, Dual II Magnum®, Charger Basic®, and Cinch®. 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.

s-metolachlor (2.4 lbs. per gallon) plus atrazine (3.1 lbs. per gallon) products at 1.3-2.6 pts. per acre — including the following: Bicep II Magnum®, Cinch ATZ®, and Charger Max ATZ®. Or s-metolachlor (3.33 lbs. per gallon) plus atrazine (2.67 lbs. per gallon) at 0.9-2.2 pts. per acre — including the following: Bicep Lite II Magnum®, Cinch ATZ Lite®, Charger Max ATZ Lite®. 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. 30-day PHI. **RUP.**

**Zidua®** at 1.0-4 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. 37-day PHI.

### Preemergence Broadleaves

**Recommended Products**

**Callisto®** at 6-7.7 fl. oz. per acre. Processing and fresh market varieties. Some varieties may be severely injured. Adding atrazine at 0.75 lb a.i. per acre will improve weed control. Peas are very sensitive to Callisto®, observe rotation and drift management recommendations. Note organophosphate insecticide precautions. Not recommended if products containing mesotrione (e.g., Lexar® or Lumax®) or topramezone (e.g., Impact®) have been (or will be) applied to crop. Do not exceed 0.24 lb. mesotrione per acre per year (7.7 fl. oz. Callisto®) from all sources. 45-day PHI.

### Postemergence Grasses and Broadleaves

**Recommended Products**

**Accent Q®** at 0.45-0.9 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.

**Impact 75DG®** at 0.5-0.75 oz. per acre. Apply with 1.0-1.5% v/v COC or MSO, with UAN at 1.25-2.5 % v/v, or with AMS at 8.5-17 lbs. per acre. Tank-mixing with atrazine will improve efficacy and spectrum of weed species controlled. Not recommended to be tank-mixed with, or applied sequentially to products that contain mesotrione (Callisto® products). 45-day PHI.

**Laudis 3.5SC®** at 3 oz. per acre. Apply with 1% v/v MSO plus 8.5 lbs. of AMS per 100 gals. 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.

**Liberty 280 SL®** at 20 fl oz. per acre with AMS after emergence until 24 inches tall or V-7 stage, whichever comes first. Apply only to tolerant corn labeled as LibertyLink® or total crop will be destroyed. May make 2 applications per year. Supplemental label valid through November 5, 2016. 0- to 180-day plant back interval (see label). 2-day PHI.

**Option 35WDG®** at 1.5-1.75 oz. per acre. Apply with MSO at 1.5 pts. per acre with either AMS at 1.5-3 lbs. per acre, or UAN at 1.5-2 qts. per acre. Not recommended or precautions apply for use on corn previously treated with Counter®, Lorsban®, or Thimet® insecticides (see labels). Possible hybrid sensitivity. 45-day PHI.

**Revulin Q 52.2 WDG®** at 3.4 to 4.0 oz. per acre 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. 45-day PHI.

**Roundup PowerMax®** or **Roundup WeatherMax®** at 0.66-3.3 qts. per acre before corn emerges, or at 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 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. 7-day PHI. 30-day PHI if corn is harvested for forage or grain.

### Postemergence Broadleaves

**Recommended Products**

2, 4-D formulations at the following rates:

**Amine formulations** at 0.25-0.75 lb. a.i. per acre.

**4L 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 within 2 weeks of tasseling through harvest. Avoid drift onto other vegetable crops. Can cause severe injury to some varieties.

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This is a reduced-risk pesticide. See page 37 for details.
Aim EC® at 0.5 fl. oz. per acre. Use 8 fl. oz. of NIS per 25 gals. of spray solution. Apply to weeds up to 4 inches tall and apply up to the 14 leaf-collar stage of sweet corn. To reduce injury, the label requires using drop nozzles or other directed sprayers to minimize application to the whorl. Do not exceed 2 fl. oz. of Aim EC® per acre per season.

Anthem ATZ® at 1.5-3 pts. per acre depending on soil texture (check label). For processing sweet corn only when used postemergence. For control of several broadleaf weeds. Apply from crop emergence through V4 growth stage. Most broadleaf weeds need to be less than 4 inches tall. 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. 45-day PHI.

Anthem Maxx® at 2.5-6 fl. oz. per acre depending on soil texture (check label). For processing sweet corn only when used postemergence. For control of several broadleaf weeds. Most broadleaf weeds need to be less than 2 inches tall. 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. 45-day PHI.

Bentazon products at 0.75-1 lb. a.i. per acre. Use 4L formulations at 0.75-1 qt. per acre. Use 1 qt. of COC per acre. 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.

Cadet® at 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. 40-day PHI.

Callisto® at 3 oz. per acre. Processing and fresh market varieties. Some varieties may be severely injured. Include NIS at 0.25% v/v or COC at 1.0% v/v. Adding NIS is preferable to COC to reduce crop injury. COC will improve weed control under dry conditions. Do not add UAN or AMS. Adding atrazine at 0.25-0.5 lb. of a.i. per acre will improve weed control. Peas are very sensitive to Callisto®; observe rotation and drift management recommendations. Note organophosphate insecticide precautions. Not recommended if products containing mesotrione (e.g., Lexar® or Lumax®) or topramezone (e.g., Impact®) have been (or will be) applied to crop. Do not exceed 0.24 lb. mesotrione per acre per year (7.7 fl. oz. Callisto®) from all sources. 45-day PHI.

Callisto Xtra® at 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. 45-day PHI.

Halosulfuron products, including Sandea® or Permit®, at 2/3-1 oz. per acre. 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. 30-day PHI.

Starane 1.5L® at 0.66 pt. per acre, or Starane Ultra 2.8L® at 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. 31-day PHI.

Stinger 3L® at 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. 30-day PHI.

Topramezone products at the following rates:

Impact® at 0.5-0.75 fl. oz. per acre. Do not exceed 0.75 fl. oz. per acre.

Armezon® at 0.5 to 1.0 fl. oz. per acre. Do not exceed 1.0 fl. oz. per season.

Add MSO or COC and urea ammonium nitrate (UAN), ammonium phosphate (10-34-0), or ammonium sulfate. See specific label for additive rates as they vary slightly between products. Not recommended if products containing mesotrione have been or will be applied to crop. 45-day PHI.

Postemergence Grasses

Recommended Products

Poast® at 0.75-1.5 pts. per acre. Poast Protected® varieties only — will kill other crops. Use 1 pt. Dash®, 1.5 pts. MSO, or 2 pts. COC per acre. UAN or AMS are optional, see label. For use only on Poast®-tolerant sweet corn varieties. Such varieties are clearly labeled. May repeat applications up to 3.0 pts. Poast® total per acre per season. 30-day PHI.
Insect Control

Seedcorn Maggots, Seedcorn Beetles, Wireworms
Plant seed that has been treated with an insecticide prior to planting. Use diazinon, Cruiser®, or Poncho®. Follow label directions.

Although most sweet corn seed has been treated with a fungicide, it is seldom treated with an insecticide to prevent seed and seedling damage.

Recommended Products
Aztec 2.1G* at 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 or drag chains. RUP.

Brigade* (2EC) at 0.15-0.3 fl. oz. per 1,000 linear ft. of row. Apply in furrow or T-band. May be applied in conjunction with pop-up fertilizers. Also controls cutworms and grubs. Do not exceed 0.1 lb. a.i. per acre per season at plant application. 30-day PHI. RUP.

Capture LFR® at 0.2-0.39 fl. oz. per 1,000 linear ft. of row at planting. See label. RUP.

Force CS* at 0.46-0.57 fl. oz. per 1,000 linear ft. of row at planting. Apply as a T-band or in furrow. See label. Do not exceed 1 application per crop. RUP.

Lorsban* (15G) at 8 oz. per 1,000 linear ft. of row. Apply as a 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. RUP.

Mocap 15G* at 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. RUP.

Thimet 20G® at 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. RUP.

Warrior II* (2.08EC) at 0.33 oz. per 1,000 linear ft. of row. Apply in furrow or as a 5- to 7-inch band. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. RUP.

Corn Leaf Aphid
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 these infestations in check.

Although infestations can exceed 100 aphids per plant on more than 50% of the plants, pollination is rarely affected. Fresh market growers may need to spray to avoid aphid colonies on the husks or sticky honeydew (excreted by aphids) on the husks. Choose products that will control both caterpillar pests (corn earworm, European corn borer, fall armyworm) and aphids if both are a problem.

Recommended Products
Assail 30SG® at 2.1-2.9 oz. per acre. Do not exceed 2 applications per season. 1-day PHI. RUP.

Lannate LV® (2.4WSL) at 0.75-1.5 pts. per acre. Do not exceed 6.3 lbs. a.i. per acre per crop. 0-day PHI for ears. 3-day PHI for forage. RUP.

Corn Rootworm Adults
Most of the insecticides listed below for control of European corn borer, corn earworm, and armyworms also control corn rootworm beetles. Those that do not control corn rootworm beetles are Coragen®, Entrust®, Intrepid®, and Radiant®.

Corn rootworm adults may prevent pollination by feeding on green silks. Treat when silks are being clipped.
**Cutworms**

**Recommended Products**

Ambush® (2SC) at 6.4-12.8 fl. oz. per acre. Do not exceed 76 fl. oz. per acre per season. 1-day PHI. *RUP.*

Asana XL® (0.66EC) at 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. 1-day PHI. *RUP.*

Baythroid XL® (1EC) at 0.8-1.6 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. 0-day PHI. *RUP.*

Brigade® (2EC) at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 1-day PHI. *RUP.*

Lorsban 4E® at 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. 21-day PHI. *RUP.*

Mustang Maxx® (0.8EC) at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 3-day PHI. *RUP.*

Pounce 25WP® at 6.4-12.8 oz. per acre. Do not exceed 4.8 lbs. per acre per season. 1-day PHI.

Warrior II® (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. 1-day PHI. *RUP.*

**European Corn Borer, Corn Earworm, Fall Armyworm**

**European Corn Borer Threshold**

More than 10 moths per night in a black light traps while corn is in late whorl stage.

**Corn Earworm Threshold**

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.

**Fall Armyworm Threshold**

Moths being caught in pheromone traps or larval damage present while corn is in late whorl stage.

**Recommended Products**

Ambush® (2SC) at 6.4-12.8 oz. per acre. Do not exceed 76 fl. oz. per acre per season. Control is poor when temperatures are above 90°F. 1-day PHI. *RUP.*

Asana XL® (0.66EC) at 5.8-9.6 fl. oz. per acre. *Corn earworm only.* Do not exceed 96 fl. oz. per acre per season. 1-day PHI. *RUP.*

Baythroid XL® (1EC) at 1.6-2.8 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. 0-day PHI. *RUP.*

Besiege® at 6-10 fl. oz. per acre. Do not exceed 31 fl. oz. per acre per season. 1-day PHI. *RUP.*

**Blackhawk®** at 1.67-3.3 oz. per acre. 1-day PHI.

Brigade® (2EC) at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 1-day PHI. *RUP.*

Coragen® (1.67SC) at 3.5-5 fl. oz. per acre. Do not exceed 15.4 fl. oz. per acre per season. 1-day PHI.

Entrust® (2SC) at 1.5-6 fl. oz. per acre. More effective for European corn borers than corn earworms. Do not exceed 29 fl. oz. per acre per season. Also see labels for Entrust® WP. Observe resistance management restrictions. 1-day PHI.

Intrepid 2F® at 4-16 fl. oz. per acre. *European corn borer only.* Do not exceed 64 fl. oz. per acre per season. 3-day PHI.

Lannate LV® (2.4W) at 0.75-1.5 pts. per acre. *European corn borer only.* Do not exceed 21 pts. per acre per crop. 0-day PHI for ears. 3-day PHI for forage. *RUP.*

Warrior II® (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. 1-day PHI. *RUP.*

Pounce 25WP® at 6.4-12.8 oz. per acre. Do not exceed 4.8 lbs. per acre per season. Control is poor when temperatures are above 90°F. 1-day PHI.

Radiant SC® at 3-6 fl. oz. per acre. Do not exceed 30 fl. oz. per acre per season. Do not make applications less than 4 days apart. 1-day PHI.

Sevin XLR PLUS® (4F) at 1.5-2 qts. per acre. Do not exceed 8 applications or 16 qts. per acre per season. Machine harvest only. 2-day PHI.

Warrior II® (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. 1-day PHI. *RUP.*

**Monitoring European Corn Borer and Corn Earworm**

One of the keys to successfully managing European corn borers and corn earworms on sweet corn is to determine when the insects are active. European corn borers can be monitored effectively with blacklight traps and field observations, and corn earworms can be monitored with pheromone traps. 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 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.

May be acceptable for use in certified organic production. Check with your certifier before use.
Because these two insects' egg laying behavior differ, control strategies also differ. Corn borers can be controlled by spraying during the late whorl, tasselling, and silking stages. The migrating larvae should contact a lethal dose of insecticide while moving to the ear zone. Corn earworms must be controlled by directing sprays at the silks so larvae will immediately contact the insecticide after hatching.

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.

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 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.

Obviously, growers should not treat separately for these two pests. Some of the insecticides recommended here are effective against both species. Choose an insecticide that will adequately control both.

**Sources of Corn Earworm and European Corn Borer Traps**

Bob Poppe's Service  
25738 N. 3200 East  
Lexington, IL 61753  
(309) 275-5477

**Sources of Pheromones/Traps**

Gempler's  
P.O. Box 270  
100 Countryside Drive  
Belleville, WI 53508  
(800) 382-8473  
www.gemplers.com

Great Lakes IPM  
10220 Church Road  
Vestaburg, MI 48891-9746  
(989) 268-5693  
www.greatlakesipm.com

Insects Limited Inc.  
16950 Westfield Park Road  
Westfield, IN 46074-9374  
(317) 896-9300  
www.insectslimited.com

**Pacific Biocontrol Corporation**  
620 E. Bird Lane  
Litchfield Park, AZ 85340  
(623) 935-0512 or (800) 999-8805  
www.pacificbiocontrol.com

**Scentry Biologicals, Inc.**  
610 Central Avenue  
Billings, MT 59102  
(800) 735-5323  
www.scentry.com

**Trece Incorporated**  
PO Box 129  
Adair, OK 74330  
(866) 785-1313  
www.trece.com

**Flea Beetles**

Plant varieties that are resistant to Stewart's wilt, which is vectored by flea beetles.

**Recommended Products**

- **Ambush** (2SC) at 6.4-12.8 oz. per acre. Do not exceed 1.2 lbs. a.i. per acre per season. 1-day PHI. RUP.
- **Asana XL** (0.66EC) at 5.8-9.6 fl. oz. per acre. Do not exceed 96 fl. oz. per acre per season. 1-day PHI.
- **Baythroid XL** (1EC) at 0.8-1.6 fl. oz. per acre. Do not exceed 28 fl. oz. per acre per season. 0-day PHI. RUP.
- **Brigade** (2EC) at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 1-day PHI. RUP.
- **Lannate LV** (2.4WSL) at 0.75-1.5 pts. per acre. Do not exceed 21 pts. per acre per crop. 0-day PHI for ears. 3-day PHI for forage. RUP.
- **Lorsban 4E** at 1-2 pts. per acre. Do not exceed 15 pts. per acre per crop. 21-day PHI. RUP.
- **Mustang Maxx** (0.8EC) at 2.24-4.0 fl. oz. per acre. Do not exceed 24 fl. oz. per acre per season. 3-day PHI. RUP.
- **Pounce 25WP** at 6.4-12.8 oz. per acre. Do not exceed 4.8 lbs. per acre per season. 1-day PHI. RUP.
- **Sevin XLR PLUS** (4F) at 1-2 qts. per acre. Do not exceed 8 applications or 16 qts. per acre per season. Machine harvest only. 2-day PHI.
- **Warrior II** (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. 1-day PHI. RUP.

**Stink Bugs (including Brown Marmorated Stink Bug)**

- **Baythroid XL** (1EC) at 2.1-6.4 fl. oz. per acre. Do not exceed 12.8 fl. oz. per acre per season. 1-day PHI. RUP.
- **Hero** at 4-10.3 fl. oz. per acre. Do not exceed 27.39 fl. oz. per acre per season. 3-day PHI. RUP.
- **Lannate LV** (2.4WSL) at 0.75-1.5 pts. per acre. Do not exceed 21 pts. per acre per crop. 0-day PHI for ears. 3-day PHI for forage. RUP.
- **Warrior II** (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 30.72 fl. oz. per acre per season. 1-day PHI. RUP.
Sweet Potato

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beauregard</td>
<td>Early, light red skin, orange flesh, increasingly popular</td>
</tr>
<tr>
<td>Centennial</td>
<td>Soft-fleshed type, orange skin</td>
</tr>
<tr>
<td>Covington</td>
<td>Orange-fleshed, smooth-skinned, rose-colored, 5-10 days later than Beauregard. Resistant to Fusarium wilt, southern root-knot nematode, and moderately resistant to streptomycetes soil rot.</td>
</tr>
<tr>
<td>Hernandez</td>
<td>Copper skin, deep orange flesh</td>
</tr>
<tr>
<td>Julian</td>
<td>Deep orange, good quality (same as Centennial)</td>
</tr>
<tr>
<td>Nugget</td>
<td>Firm-fleshed type, orange skin, orange flesh, good quality, excellent keeper</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For Trial</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carolina Ruby</td>
<td>Dark red skin, orange flesh</td>
</tr>
</tbody>
</table>

**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. Where internal cork is present, obtain seed stock from suppliers who have cork-free 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 2,000 to 2,500 plants (slips) from three pullings.

Treating seed before planting with Mertect 340-F® will protect roots from infection by certain disease-causing organisms. Bed the seed stock in new, clean sand taken from upland banks or pits. Allow 10 to 12 square feet of bed area per bushel of seed. Maintain plant bed temperature at 75°F to 85°F.

**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. $P_2O_5$: 0 to 75 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. 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. Dig only those potatoes that can be picked up immediately and not left out overnight. Temperatures below 50°F can chill potatoes and cause internal breakdown in storage. Potatoes will sunburn if left in direct sunlight for more than an hour. Field grading is important.

Prevent skinning and breaking. Use cotton gloves when placing potatoes in crates. Place well-shaped No. 1’s with No. 2’s, and cuts with culls.

**Storing**

When the storage house is filled, raise the temperature to 85°F. Keep it at this temperature for 6 to 8 days, with 85 percent to 90 percent humidity for proper curing. After curing, the temperature may be gradually dropped to 55°F. Hold this temperature until potatoes are marketed or used for producing slips.

**Disease Control**

**Black Rot, Foot Rot, Fusarium Wilt, and Scurf**

Plant disease-free seed and/or resistant varieties. Follow 3-4 year crop rotations. Prevent bruising and maintain proper storage temperatures.

**Recommended Products**

_botran 75W® or Botran 5F®_ as a seed dip or plant bed spray. _Scurf only._

_mertect 340F® at 8 fl. oz. per 7.5 gals. Of water. Not for Fusarium wilt._

**Storage Rots**

Fumigate storage boxes. Cure and store only healthy, blemish-free tubers.
**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 Table 25 on page 66.

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 Applications Broadleaves and Grasses

**Recommended Products**

- **Glyphosate**
  - Products at 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 planting, 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. 14-day PHI.

### Preemergence Broadleaves and Grasses

**Recommended Products**

- **Command 3ME®** at 1.3-4 pts. per acre. Use low rate on coarse soils. Apply before planting, or apply up to 1.5 pts. per acre after transplanting and before weeds emerge. 95-day PHI for rates up to 3.3 pts. per acre. 125-day PHI for rates more than 3.3 pts. per acre.
- **Devrinol 50DF-XT®** at 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.
- **Dual Magnum®** at 1-1.33 pts. per acre. Apply after transplanting before weeds emerge. Do not incorporate into soil. Close transplant trenches before application. *Growers in Michigan should be in possession of the 24(c) label.* 60-day PHI.
- **Valor SX®** at 2 oz. per acre. Apply 2-5 days before 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. Do not exceed 2.5 oz. per acre per growing season.

### Preemergence Grasses

**Recommended Products**

- **Dacthal W-75®** at 6-14 lbs. per acre, or **Dacthal Flowable®** at 6-14 pts. per acre. Apply at transplanting or layby. May be applied over the top of transplants.

### Postemergence Broadleaves and Grasses

**Recommended Products**

- **Aim EC®** at 0.5-2 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.
- **Fusilade DX 2E®** at 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 actively growing grass. Do not exceed 48 fl. oz. per acre per season. 55-day PHI.
- **Poast 1.5E®** at 1-1.5 pts. per acre. Use 1 qt. of COC per acre. Spray on actively growing grass. Do not exceed 5 pts. per acre per year. 30-day PHI.
- **Select Max®** at 12-32 fl. oz per acre, or **Select 2EC®** at 6-16 fl. oz. per acre. Use 1 qt. of COC per 25 gals. of spray solution (1% v/v). Spray on actively growing grass. Wait at least 14 days between applications. Do not exceed 64 fl. oz. of Select Max®, or 32 fl. oz. of Select 2EC® per acre per season. 30-day PHI.

**Aphids**

**Recommended Products**

- **Actara® (25WDG)** at 3 oz. per acre. Do not exceed 6 oz. per acre per season. 14-day PHI.
- **Admire PRO® (4.6F)** at the following rates:
  - **Soil applications:** 4.4-10.5 fl. oz. per acre. 125-day PHI.
  - **Foliar applications:** 1.2 fl. oz. per acre. 7-day PHI.

This is a reduced-risk pesticide. See page 37 for details.
**Sweet Potato - Insect Control**

**Assail 30SG** at 2.5-4 oz. per acre. 7-day PHI.

**Belay 2.13SC** at 2-3 fl. oz. per acre. 14-day PHI.

**Beleaf 50SG** at 2-2.8 oz per acre. 7-day PHI.

**Fulfill** (50WDG) at 2.75-5.50 oz. per acre. 14-day PHI.

**Malathion** (5 EC) at 1.5-2 pts. per acre. 3-day PHI.

**Movento** (2SC) at 4-5 fl. oz. per acre. 7-day PHI.

**Platinum** (2SC) at 5-8 fl. oz. per acre. Apply at planting.

**Pyrenone** at 1-12 fl oz. per acre. 0 day PHI.

**Sivanto** (200SL) at 7-10.5 fl. oz. per acre. Apply at planting or as foliar spray. 7-day PHI.

**Warrior II** (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. **RUP.**

**Colorado Potato Beetles**

**Recommended Products**

**Actara** (25WDG) at 1.5-3 oz. per acre. Do not exceed 6 oz. per acre per season. 14-day PHI.

**Assail 30SG** at 1.5-4 oz. per acre. 7-day PHI.

**Avault** (30WDG) at 3.5-6 oz. per acre. 7-day PHI.

**Baythroid XL** (1EC) at 1.6-2.8 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. **RUP.**

**Belay** (2.13SC) at 2-3 fl. oz. per acre. 14-day PHI.

**Entrust** (2SC) at 3.6 fl. oz. per acre. 7-day PHI.

**Mustang Maxx** (0.8EC) at 3.2-4 fl. oz. per acre. 1-day PHI. **RUP.**

**Radiant SC** at 4.5-8 fl. oz. per acre. Do not exceed 32 fl. oz. per acre per season. 7-day PHI.

**Sivanto** (0.83EC) at 6-12 fl. oz. per acre. Do not exceed 24 fl. oz. or 2 applications per acre per season. 14-day PHI.

**Rimon** (200SL) at 10.5-14 fl. oz. per acre at planting or as foliar spray.

**Warrior II** (2.08EC) at 1.28-1.92 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. **RUP.**

**Potato Leafhoppers**

**Recommended Products**

**Actara** (25WDG) at 1.5-3 oz. per acre. Do not exceed 6 oz. per acre per season. Control may require 2 applications at a 7-10 day interval. 14-day PHI.

**Admire PRO** (4.6F) at the following rates:

* **Soil applications:** 4.4-10.5 fl. oz. per acre. 125-day PHI.

* **Foliar applications:** 1.2 fl. oz. per acre. 7-day PHI.

Do not exceed 0.38 lb. a.i. or 1 application per acre per season.

**Assail 30SG** at 1.5-4 oz. per acre. 7-day PHI.

**Baythroid XL** (1EC) at 0.8-1.6 fl. oz. per acre. Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. **RUP.**

**Belay** (2.13SC) at 2-3 fl. oz. per acre. 14-day PHI.

**Malathion** (5 EC) at 1.5-2 pts. per acre. 3-day PHI.

**Mustang Maxx** (0.8EC) at 3.2-4 fl. oz. per acre. 1-day PHI. **RUP.**

**Platinum** (2SC) at 5-8 fl. oz. per acre. Apply at planting.

**Pyrenone** at 1-12 fl oz. per acre. 0 day PHI.

**Sivanto** (200SL) at 7-10.5 fl. oz. per acre at planting or as foliar spray. 7-day PHI.

**Voliam Flexi** at 4 oz. per acre. 14 day PHI.

**Warrior II** (2.08EC) at 0.96-1.6 fl. oz. per acre. Do not exceed 7.68 fl. oz. per acre per season. 7-day PHI. **RUP.**

**Wireworms, Flea Beetle Larvae**

**Recommended Products**

**Baythroid XL** (1EC) at 1.6-2.8 fl. oz. per acre. *Flea beetles only.* Do not exceed 16.8 fl. oz. per acre per season. 0-day PHI. **RUP.**

**Brigade** (2EC) at 9.6-19.2 fl. oz. per acre at planting. 21-day PHI.

**Capture LFR** at 12.75-25.5 fl. oz. per acre. *Apply at planting or layby. RUP.**

**Lorsban 15G** at 13.5 lbs. per acre Evenly distribute granules over treated area. After application, incorporate to a depth of 4-6 inches by rotary hoe or disc cultivator. Do not exceed 1 application per season. 125-day PHI. **RUP.**

**Lorsban 4E** at 4 pts. per acre, or **Lorsban 75WG** at 2.67 lbs. per acre. Apply to soil surface as a preplant broadcast spray. Incorporate immediately after application to a depth of 4-6 inches. Plant sweet potatoes no more than 14 days after treatment. Do not exceed 1 application per season. 125-day PHI. **RUP.**

**Platinum** (2SC) at 5-8 fl. oz. per acre. *Seed treatment only.* Apply at planting.

*This is a reduced-risk pesticide. See page 37 for details.*
Calibration of 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 three types of applicators.

**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 ft. boom must travel 495 ft. to cover 1/4 acre:

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

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 actual area to be band treated.

**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:

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

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:

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

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.
## Pesticide Application Record and Written Notification for EPA Worker Protection Standards

<table>
<thead>
<tr>
<th>Business Name</th>
<th>Location</th>
<th>Pesticide</th>
<th>Application</th>
<th>Name &amp; Certification No. of Applicator or Certified Supervisor</th>
<th>Date (Mo./Day/Year)</th>
<th>Time</th>
<th>Restricted Entry Interval (hrs.)</th>
<th>OK to Enter (Date &amp; Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
<td>Crop</td>
<td>Product Brand Name &amp; Chemical Formulation</td>
<td>Active Ingredient</td>
<td>Name of Manufacturer</td>
<td>EPA Registration Number</td>
<td>Pest Controlled</td>
<td>Area Treated (Sq. ft. or Acres)</td>
<td>Pesticide Rate</td>
</tr>
</tbody>
</table>

1. 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.

2. For EPA Worker Protection Standard, information in shaded columns must be recorded for all pesticides and be maintained at the centrally located posting area for 30 days after the restricted entry interval expires.

3. Formulation required if included in product name: DF=dry flowable, EC & E=emulsifiable concentrate, G=granules, F=flowable, L=liquid, S=soluble, ULV=ultra low volume, etc.

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.
Figure 1. (Left) Bacterial spot of tomato causes small necrotic lesions on leaves that are often accompanied by chlorosis. (Right) Lesions on fruit are often scabby in appearance. See page 134 for management options.

Figure 2. Bacterial spot lesions on pumpkin are light colored with water-soaked margins. The cut open pumpkin shown here has a secondarily infected lesion that has rotted through the fruit. See page 105 for management options.

Figure 3. Gummy stem blight on watermelon often turns leaf petioles light brown and produces dark brown, irregular leaf lesions. See pages 114-115 for management options.

Figure 4. (Left) Downy mildew of cucumber causes angular chlorotic lesions. (Right) During moist conditions, the fungus that causes downy mildew is visible on the undersides of infected leaves. See pages 113-114 for management options.
Figure 5. Early blight is one of the most common tomato diseases. The inset shows a close-up of early blight’s characteristic bull’s-eye lesions. See pages 135-136 for management options.

Figure 6. White mold or timber rot of tomato kills stems and entire plants. The black fungal structures (sclerotia) shown here are diagnostic of this disease. See page 137 for management options.

Figure 7. European corn borers can be a problem in peppers. See pages 143-144 for management options.

Figure 8. Seedcorn maggots can be a problem in many crops including cantaloupe. See page 122 for management options.

Figure 9. Colorado potato beetles can be a pest in many crops, including eggplant. See page 142 for management options.

Figure 10. The brown marmorated stink bug is an emerging pest in the Midwest. If you see this pest, contact your state extension specialist. More information is available from Purdue Extension at extension.entm.purdue.edu/caps/pestInfo/brownStinkBug.htm. Control information is provided for Fruiting Vegetables (pages 138-139) and Sweet Corn (page 221).
Figure 11. Corn earworm larva (left) can be a significant sweet corn pest. The adult (right) is shown for identification purposes. See page 220 for management options.

Figure 12. Indiana has confirmed the presence of western bean cutworm and it may be present in other states covered by this guide. It is not clear how much damage this pest causes. If you observe this pest, contact your state extension specialist.

Figure 13. Manganese toxicity on cantaloupe is a disorder that can occur if soil pH is too low. See pages 110-111 for soil pH and fertility recommendations for cucumber, cantaloupe, and watermelon.

Figure 14. Sunscald appears as a white, hard area on a portion of the tomato fruit. The area may later shrivel and sink in. See page 126 for details.

Figure 15. Tomato pinworm (*Keiferia lycopersicella*) is an emerging pest in the Midwest. See pages 143-144 for management options.
Figure 16. Radial (left) and concentric cracks on tomato. See page 126 for more information.

Figure 17. Zipper scars on tomatoes. See page 126 for more information.

Figure 18. Catfacing on tomato. See page 126 for more information.

Figure 19. Micro-cracks or rain checks. See page 126 for more information.

Figure 20. These roma tomatoes suffer from varying degrees of blossom end rot. See page 127 for management options.
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
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
Methodist Hospital, Clarian Health Partners
Interstate 65 at 21st Street
Indianapolis, IN 46206-1367
Emergency Number: (800) 222-1222
TTY/TDD: (317) 962-2336
Fax: (317) 962-2337
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

Kansas
Mid-America Poison Control Center
University of Kansas Medical Center
8400 KU Hospital
3901 Rainbow Boulevard
Kansas City, KS 66160-7231
Emergency Number: (800) 222-1222
Kansas City Residents May Phone: (913) 588-6633
Emergency TDD: (913) 588-6639
www.kumec.com/poison

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

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

Missouri
Missouri Poison Center
7980 Clayton Road, Suite 200
St. Louis, MO 63117
Emergency Number: (800) 222-1222
In St. Louis: (314) 772-5200
TTY/TDD: (314) 612-5705
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

Illinois Fruit & Vegetable News
www.ipm.uiuc.edu/ifvn

Iowa State University
www.extension.iastate.edu/vegetablelab

K-State Plant Pathology Extension
www.plantpath.k-state.edu/p.aspx?tabid=49

K-State Horticulture Extension
www.hfrr.ksu.edu/p.aspx?tabid=931

Michigan State University Extension Vegetables
msue.anr.msu.edu/topic/info/vegetables

Minnesota VegEdge
www.vegedge.umn.edu

Ohio VegNet
vegnet.osu.edu

Purdue Vegetable Crops Hotline
vegcropshotline.org

Purdue Horticulture Extension-Vegetable Crops
ag.purdue.edu/hla/Extension/Pages/Vegetable-Crops.aspx

Radcliffe’s IPM World Textbook
ipmworld.umn.edu

University of Missouri
www.plantsci.missouri.edu

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