PEST MANAGEMENT GUIDELINES FOR AGRICULTURE

Contents (Dates in parenthesis indicate when each topic was updated)

General Information................................................................. 1
   Relative Toxicities of Insecticides and Miticides Used in Onion and Garlic to Natural Enemies and Honey Bees (10/18).......................... 1
   General Properties Of Fungicides (6/16)................................. 3

Insects And Mites (section reviewed 10/18) .................................. 4
   Bulb Mites (10/18)............................................................... 4
   Leafminers (10/18)............................................................ 7
   Maggots (10/18)............................................................... 9
   Thrips (10/18)................................................................... 13

Diseases (section reviewed 1/07) .................................................. 17
   Bacterial Soft Rots (1/07)...................................................... 17
   Basal Rot (1/07)................................................................. 17
   Black Mold (1/07)............................................................. 18
   Blue Mold Rot (6/08)........................................................ 18
   Botrytis Leafspot (6/16)....................................................... 19
   Botrytis Neck And Bulb Rot (6/08)....................................... 20
   Downy Mildew (6/16)......................................................... 21
   Garlic Mosaic (1/07).......................................................... 23
   Iris Yellow Spot (6/09)........................................................ 23
   Onion Yellow Dwarf (1/07).................................................. 24
   Pink Root (6/16)............................................................... 25
   Purple Blotch And Stemphylium Leaf Blight (6/16).................. 27
   Rust (6/16)...................................................................... 29
   Sour Skin (1/07).............................................................. 30
   White Rot (6/16).............................................................. 31

Nematodes (1/18)..................................................................... 33

Weeds (section reviewed 10/18) .................................................. 37
   Integrated Weed Management (10/18)................................. 37
   Special Weed Problems (10/18)............................................ 43
   Common and Scientific Names of Weeds (10/18)..................... 44
   Susceptibility of Weeds To Herbicide Control (10/18).............. 45
   Herbicide Treatment Table (10/18)...................................... 47

Precautions for Using Pesticides.................................................. 53

To be used with UC/ANR Publication 3339PS3,
Color Photo Guide to Onion/Garlic Pests

The combined publications are available as
UC/ANR Publication 3339PS3A,
UC IPM Pest Management Guidelines: Onion/Garlic with color photo supplement

An illustrated version of this guideline is available online at http://ipm.ucanr.edu/PMG/selectnewpest.onion-and-garlic.html
Authors

Insects, Mites, and Other Invertebrates: S. K. Dara, UC Cooperative Extension Santa Barbara Co.; E. T. Natwick, UC Cooperative Extension Imperial Co; S. Orloff, UC Cooperative Extension Siskiyou Co.

Diseases: R. M. Davis, Plant Pathology, UC Davis; B. J. Aegerter, UC Cooperative Extension San Joaquin Co.; T. Turini, UC Cooperative Extension Fresno Co.; A. Ferry-Abee, UC Cooperative Extension Tulare and Kings counties

Nematodes: J.O. Becker, Nematology, UC Riverside; B. B. Westerdahl, Nematology, UC Davis

Weeds: R. Smith, UC Cooperative Extension Monterey Co.; S. A. Fennimore, Weed Science and Plant Sciences, UC Davis and Salinas; R. Wilson, Intermountain Research and Extension Center, Tulelake

Crop Leadership Team: T. Turini, UC Cooperative Extension Fresno Co. (crop team leader); S. K. Dara, UC Cooperative Extension Santa Barbara Co. (IPM facilitator); S. Parreira, UC IPM Program (coordinator); C. L. Swett, Plant Pathology, UC Davis; J. O. Becker, Nematology, UC Riverside; R. Smith, UC Cooperative Extension Monterey Co.

Acknowledgment for past contributions

Insects and Mites: W. E. Chaney, UC Cooperative Extension Monterey Co.; R. L. Coviello, UC Cooperative Extension Fresno Co. G. J. Poole, UC Cooperative Extension Los Angeles Co.; L. D. Godfrey, Entomology, UC Davis

Diseases: F. F. Laemmlien, UC Cooperative Extension Santa Barbara and San Luis Obispo counties; R. E. Voss, Plant Sciences, UC Davis

Nematodes: U. C. Kodira, Plant Pathology, UC Davis


About this publication

Produced and edited by:

UC Statewide IPM Program
University of California Agriculture and Natural Resources
Guidelines Coordinator: S. Parreira
Production: F. Rosa

This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Agricultural Pest Management.

The UC IPM Pest Management Guidelines are available from:

- Online: http://ipm.ucanr.edu
- UC Cooperative Extension County Offices
- University of California
- ANR Communication Services
  2801 Second Street
  Davis, CA  95616-7779
  530-750-1212; 800-994-8849

Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM website for information on updates.

Note to readers: These guidelines represent the best information currently available to the authors and are intended to help you make the best choices for an IPM program. Not all formulations or registered pesticides are mentioned. Always read the label and check with local authorities for the most up-to-date information regarding registration and restrictions on pesticide use. Check with your agricultural commissioner for latest restricted entry intervals.

This material is partially based on work supported by the National Institute of Food and Agriculture, Crop Protection and Pest Management Competitive Grants Program.
# General Information

## Relative Toxicities of Insecticides and Miticides Used in Onion and Garlic to Natural Enemies and Honey Bees (10/18)

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Mode of action</th>
<th>Selectivity&lt;sup&gt;2&lt;/sup&gt; (affected groups)</th>
<th>Predatory mites&lt;sup&gt;3&lt;/sup&gt;</th>
<th>General predators&lt;sup&gt;4&lt;/sup&gt;</th>
<th>Parasites&lt;sup&gt;4&lt;/sup&gt;</th>
<th>Honey bees&lt;sup&gt;5&lt;/sup&gt;</th>
<th>Duration of impact to natural enemies&lt;sup&gt;6&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>abamectin (Agri-Mek)</td>
<td>6</td>
<td>moderate (leafminers, mites, thrips)</td>
<td>M</td>
<td>L</td>
<td>M/H</td>
<td>I</td>
<td>moderate to predatory mites and affected insects</td>
</tr>
<tr>
<td>azadirachtin (AzaGuard)</td>
<td>un</td>
<td>broad (insects, mites)</td>
<td>M</td>
<td>L/M</td>
<td>L/M</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td>Beauveria bassiana (Mycotrol)</td>
<td>--</td>
<td>broad (insects)</td>
<td>L</td>
<td>L/M</td>
<td>L</td>
<td>II</td>
<td>--</td>
</tr>
<tr>
<td>chlorpyrifos (Lorsban)</td>
<td>1B</td>
<td>broad (insects, mites)</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate</td>
</tr>
<tr>
<td>clothianidin/imidacloprid (Sepresto)</td>
<td>4A</td>
<td>broad (insects)</td>
<td>--</td>
<td>L/M</td>
<td>L/M</td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>cyromazine (Trigard)</td>
<td>17</td>
<td>narrow (leafminers)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>II</td>
<td>none</td>
</tr>
<tr>
<td>methomyl (Lannate)</td>
<td>1A</td>
<td>broad (insects, mites)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate</td>
</tr>
<tr>
<td>spinetoram (Radiant)</td>
<td>5</td>
<td>narrow (aphids, caterpillars, leafminers, scales, thrips, whiteflies)</td>
<td>M</td>
<td>M&lt;sup&gt;8&lt;/sup&gt;</td>
<td>L/M</td>
<td>II</td>
<td>moderate&lt;sup&gt;7&lt;/sup&gt;</td>
</tr>
<tr>
<td>spinosad (Entrust, Success)</td>
<td>5</td>
<td>narrow (leafminers, thrips)</td>
<td>M</td>
<td>M&lt;sup&gt;8&lt;/sup&gt;</td>
<td>L/M</td>
<td>II</td>
<td>short to moderate</td>
</tr>
<tr>
<td>spinosad/thiamethoxam (FarMore)</td>
<td>5/4A</td>
<td>broad (insects)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>spirotetramat (Movento)</td>
<td>23</td>
<td>narrow (aphids, psyllids, scales, whiteflies)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>II</td>
<td>short</td>
</tr>
</tbody>
</table>

H = high  M = moderate  L = low  — = no information  un = unknown or uncertain mode of action

---

1. Rotate insecticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee).
2. Selectivity: Broad means it affects most groups of insects and mites; narrow means it affects only a few specific groups.
3. Generally, toxicities are to western predatory mite, Galendromus occidentalis.
4. Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific insecticide depends on factors including the application rate, environmental conditions, and life stage and species of the parasite or predator.
5. Ratings are as follows: I—Do not apply or allow to drift to plants that are flowering; II—Do not apply or allow to drift to plants that are flowering, except when the application is made between sunset and midnight if allowed by the pesticide label and regulations; III—No bee precaution, except when required by the pesticide label or regulations. For more information about pesticide synergistic effects, see Bee Precaution Pesticide Ratings.
6. Duration: Short means hours to days; moderate means days to 2 weeks; and long means many weeks or months.
7. Residual is moderate if solution is between pH of 7 to 8.
8. Toxic against some natural enemies (predatory beetles, lacewing larvae, syrphid fly larvae, and predatory thrips) when sprayed and up to 5 to 7 days after, especially for syrphid fly larvae.

Illustrated version at http://ipm.ucanr.edu/PMG/selectnewpest.onion-and-garlic.html
Acknowledgments: This table was compiled based on research data and experience of University of California scientists who work on a variety of crops and contribute to the Pest Management Guideline database, and from Flint, M.L. and S.H. Dreistadt. 1998. Natural Enemies Handbook: An Illustrated Guide to Biological Pest Control, ANR Publication 3386.
## GENERAL PROPERTIES OF FUNGICIDES (6/16)

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Chemical class</th>
<th>Activity</th>
<th>Mode of action (FRAC)</th>
<th>Resistance potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>azoxystrobin (Quadris)</td>
<td>QoI</td>
<td>contact, systemic</td>
<td>single-site (11)</td>
<td>high</td>
</tr>
<tr>
<td>azoxystrobin / propiconazole (Quilt Xcel)</td>
<td>QoI/DMI</td>
<td>contact, systemic</td>
<td>multi-site (11/3)</td>
<td>—</td>
</tr>
<tr>
<td>bosalid (Endura)</td>
<td>SDHÍ</td>
<td>systemic</td>
<td>single-site (7)</td>
<td>med to high</td>
</tr>
<tr>
<td>chlorothalonil (Bravo)</td>
<td>aromatic nitrile</td>
<td>contact</td>
<td>multi-site (M4)</td>
<td>low</td>
</tr>
<tr>
<td>copper</td>
<td>inorganic</td>
<td>contact</td>
<td>multi-site (M1)</td>
<td>low</td>
</tr>
<tr>
<td>dimethomorph (Forum)</td>
<td>carboxilic acid amides</td>
<td>systemic</td>
<td>single-site (40)</td>
<td>low to med</td>
</tr>
<tr>
<td>fenamidone (Reason)</td>
<td>QoI</td>
<td>contact &amp; systemic</td>
<td>single-site (11)</td>
<td>high</td>
</tr>
<tr>
<td>fludioxinil (Cannonball)</td>
<td>phenil pyroles</td>
<td>contact</td>
<td>single-site (12)</td>
<td>low-med</td>
</tr>
<tr>
<td>iprodione (Rovral)</td>
<td>dicarboximide</td>
<td>systemic (local)</td>
<td>multi-site (M1)</td>
<td>low</td>
</tr>
<tr>
<td>mane b</td>
<td>carbamate (EBDC)</td>
<td>contact</td>
<td>multi-site (M3)</td>
<td>low</td>
</tr>
<tr>
<td>mefenoxam (Ridomil Gold, Ultra Flourish)</td>
<td>acylalanine</td>
<td>systemic</td>
<td>single-site (4)</td>
<td>high</td>
</tr>
<tr>
<td>pyraclostrobin (Cabrio)</td>
<td>QoI</td>
<td>contact &amp; translaminar</td>
<td>single-site (11)</td>
<td>high</td>
</tr>
<tr>
<td>tebuconazole (Orius)</td>
<td>DMI-triazole</td>
<td>systemic (local)</td>
<td>single-site (3)</td>
<td>high</td>
</tr>
</tbody>
</table>

— = no information

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

2 QoI = quinone outside inhibitor (strobilurin).

3 DMI = demethylation (sterol) inhibitor.

4 SDHI = succinate dehydrogenase inhibitors

Information from: Fungicide Resistance Action Committee (http://frac.info/)
Insects and Mites

BULB MITES (10/18)

Scientific Names:
- Acarid bulb mites: Rhizoglyphus spp., Tyrophagus spp.
- Dry bulb mite: Aceria tulipae
- Wheat curl mite: Aceria tosichella

DESCRIPTION OF THE PESTS

There are two groups of bulb mites that can infest onion and garlic:
1. Mites in the family Acaridae, which are round and look like tiny pearls.
2. Mites in the family Eriophyidae, called dry bulb mite and wheat curl mite. These mites are elongate and banana-shaped or wormlike.

Both groups of mites can infest onion and garlic both in the field and in storage. They can survive on decaying vegetation in the field until it is completely decomposed. These pests are not currently a problem in the low desert region.

Acarid Mites

Bulb mites in the family Acaridae are shiny, creamy-white, and bulb-shaped. They are between 0.02 to 0.04 inches (0.5–1 mm) long and have brown legs. These mites generally occur in clusters and inhabit damaged areas under the root plate of onion bulbs or garlic cloves.

Females lay eggs singly or in clusters of up to 100 eggs on damaged or decaying tissue on the bulb surface. Larvae have three pairs of legs, while nymphs and adults have four pairs of legs. All stages feed on the crop.

These mites have a wide host range, and feed on germinating seeds, bulbs, roots, and tubers of various plant species.

Eriophyid Mites: Dry Bulb Mite and Wheat Curl Mite

The dry bulb mite and wheat curl mite are smaller and more elongate than the other bulb mites, which are globular. These mites are microscopic, white, wormlike organisms of about 0.01 inch (0.25 mm). They have four legs that are located near the head.

In addition to onion and garlic, the dry bulb mite also feeds on liliaceous bulbs such as tulips. The wheat curl mite primarily feeds on cereal grains and wild grasses but occasionally feeds on onion and garlic as well.

DAMAGE

Bulb mites can stunt plant growth and reduce the onion or garlic stand. These mites also promote the rot of bulbs in storage by penetrating the outer layer of bulb tissue and allowing rot-causing pathogens to gain entry.

Acarid Mites

Bulb mites in this group are most damaging in cool, wet weather, when plant growth is slow. In direct-seeded onion, they can cut off the radicle before the plant becomes established, reducing the stand and creating gaps in the seed lines where weeds may grow.

Dry Bulb Mite and Wheat Curl Mite

Feeding by the dry bulb mite and wheat curl mite also causes stored onions and garlic to desiccate. Feeding injury during storage produces sunken brown spots and streaks on garlic cloves. Heavy field infestations in the field may also cause streaking and twisting of garlic leaves and reduce both the plant stand and yield. Damage from these mites on stored bulbs is rare in California, and the dry bulb mite more commonly infests onion and garlic than the wheat curl mite.
MANAGEMENT

Cultural Control
Culturally manage these mites with the following methods:

- Use only clean seed cloves when planting garlic.
- Avoid planting successive onion or garlic crops and rotate with crops that are less susceptible to bulb mite damage.
- Avoid planting onion or garlic immediately after Brassica species, corn, grain, sudangrass, or grass cover crops.
- Consider treating garlic seed cloves with hot water (130°F for 10–20 minutes) before planting. **Note:** although this practice may reduce mite infestations, it can also decrease germination.
- Flood irrigation or heavy rains during the winter may also reduce mite numbers in the soil.
- The normal drying process before storage can destroy light to moderate infestations.
- In other states, soaking seeds in 2% soap (not detergent) and 2% mineral oil for 24 hours before planting has successfully reduced mite infestations; however, this method has not been evaluated in California.

Acarid Mites
In addition to the cultural methods listed above, allow complete decomposition of organic material by leaving fields unplanted (fallow) between the harvest of the previous crop and the start of the next crop. Rapid rotation from one crop to the next fosters survival of mites on the leftover vegetation in the soil from the previous crop. Decaying cole crops, especially cauliflower, may harbor very high numbers of Acarid mites.

Monitoring and Treatment Decisions
No specific monitoring methods or action thresholds are available. Use a microscope to examine fragments of un decayed vegetation in the soil or volunteer onions or garlic for the presence of the mites. For dry bulb mite and wheat curl mite, examine the surface of garlic seed cloves under a microscope to determine if these mites are present. See Identifying Pests of Onion and Garlic and Their Damage for mite photos and identification tips.

Pesticide applications for Acarid mites are generally preventive and should be considered for fields that are high in vegetative matter or that have had previous bulb mite problems. However, allowing complete decomposition of organic matter in the soil before planting is the key to managing these pests.

Pesticide applications are generally not necessary for dry bulb mite and wheat curl mite because damage from these mites rarely occurs in California.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREPLANT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. METAM SODIUM*§ (Vapam HL)</td>
<td>37.5–75 gal</td>
<td>See label</td>
<td>NA</td>
</tr>
</tbody>
</table>

COMMENTS: Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.
§ Do not exceed the maximum rates allowed under the California Code of Regulations Restricted Materials Use Requirements, which may be lower than maximum label rates.

NA Not applicable
LEAFMINERS (10/18)
Scientific Name: *Liriomyza* spp.

DESCRIPTION OF THE PESTS
Adults are small black-and-yellow flies. Females puncture the leaf in a linear fashion to feed on plant sap and lay eggs within the leaf tissue. Both male and female leafminer flies feed on the sap from these punctures. The stippling of the puncture wounds becomes more visible over time as the damaged tissue dries and turns to white scar tissue. Eggs hatch within 2 to 4 days, and the small (less than 2.5 mm), white-to-yellow larvae tunnel within the leaf tissue. Larger larvae may feed inside the hollow leaves of onions or garlic, but still produce the characteristic "mines" visible from the outside of the leaf. Larvae exit the leaf upon completion of their development, and either pupate in the soil or in the leaf axils. Many generations occur each year, and the specific number of generations per year varies between growing regions. Leafminers may also overwinter as pupae in the soil and emerge the following spring.

DAMAGE
Damage caused by leafminers is primarily cosmetic; however, contamination by pupae and larvae is a marketing problem for green bunching onions. Damage in dry onions and garlic is rarely a concern unless leafminers become so numerous that they prematurely kill foliage.

Leafminers attack a wide variety of crops, including vegetables such as lettuce, celery, and spinach. The potential for damage to onion and garlic will be higher when other hosts are grown nearby.

MANAGEMENT
Biological Control
Natural enemies, especially parasitic wasps, can reduce leafminer numbers. However, these wasps are very susceptible to insecticide sprays, so they may not be reliable or effective in fields where insecticides have been used.

Cultural Control
To culturally control leafminers:
- Thoroughly work fields previously planted with susceptible crops before planting onion.
- Allow at least two weeks for leafminer flies to emerge from pupae in the soil before planting onion in a field that previously had a leafminer problem.

Organically Acceptable Methods
Biological control by naturally occurring predators and parasites is often effective in controlling this pest in organically grown onion and garlic crops. However, supplemental releases of commercially available natural enemies are rarely economically viable. Cultural controls as described above are critical. Azadirachtin products and the Entrust formulation of spinosad can also be used.

Monitoring and Treatment Decisions
There is no established threshold for leafminers in onions. Because large numbers of adults do not always lead to large larval infestations, make your management decisions based on the number of larvae on the crop and the type of onion crop.

See Identifying Pests of Onion and Garlic and Their Damage for leafminers photos and identification tips.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
</table>

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the...
top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Always read the label of the product being used.

A. CYROMAZINE
   (Trigard) 2.66 oz 12 7
   MODE-OF-ACTION GROUP NUMBER*: 17
   COMMENTS: Do not make more than six applications per crop.

B. SPINOSAD
   (Success) 3–6 fl oz 4 1
   (Entrust)# 1–2 oz 4 1
   MODE-OF-ACTION GROUP NUMBER*: 5

C. AZADIRACHTIN#
   (AzaGuard) 10–16 fl oz 4 0
   MODE-OF-ACTION GROUP NUMBER*: un
   COMMENTS: A restricted-use pesticide in an organically certified crop.

† Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

# Acceptable for use on organically grown produce.

1 Rotate insecticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. Mode-of-action group numbers (un = unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee).
MAGGOTS (10/18)

Scientific Names: Seedcorn maggot: *Delia platura*
Onion maggot: *Delia antiqua*

DESCRIPTION OF THE PESTS
Adults of *Delia* species are small gray flies. When at rest, they keep their wings folded one over the other. Onion maggot flies are similar in size to house flies. Seedcorn maggot flies, however, are significantly smaller, ranging from between 1/2 to 2/3 the size of onion maggot flies.

Larvae (maggots) are creamy-white, legless maggots that are about 0.4 inch (10 mm) long. Microscopic examination is required to distinguish between species.

Female flies lay white, elongated eggs on or near the soil surface near the base of the onion plant. Maggots prefer cool, moist soils heavy in organic matter, where they can survive and move to seeds. Seedcorn maggots more commonly move to seeds than do onion maggots. Mature larvae pupate in the soil.

Maggots have several generations per year. Seedcorn maggots occur throughout California garlic and onion production areas, while onion maggots are more restricted to cooler coastal climates and the intermountain region. Maggots are generally not a problem to onion production in the low desert region.

DAMAGE
Larvae feed on the epicotyl (developing shoot) and young roots of the developing seedling. Seedcorn maggots feed on the seed and may damage onion plants as late as the 3- to 4-leaf stages.

The first generation of onion maggots primarily feeds on seedlings, up to the 3- to 5-leaf stages. The second and third generation of onion maggots will feed on the expanding bulb of the maturing plant, which can increase bulb rot during storage.

Maggots are serious pests of onions in California, but do not generally cause economic damage to garlic. Without proper planning and insecticide controls, these pests cause onion growers to lose more than 50% of their yields.

See Identifying Pests of Onion and Garlic and Their Damage for photos of maggots and their damage, as well as identification tips.

MANAGEMENT
Prevention is the key to avoiding damage from onion and seedcorn maggot, and insecticides should be applied when maggot infestations are expected.

Cultural Control
Delaying planting is an important cultural practice to reduce damage from maggots, though this may be less feasible in cooler climates with shorter growing seasons. The amount of time to delay planting differs for onion maggot and seedcorn maggot.

For onion maggot, wait to plant until later in the spring, after the first generation of adult flies has emerged. This will avoid the first generation of egg-laying by adult flies that overwintered in the soil during the previous year. Choose when to plant by calculating the accumulation of degree-days of average daily air temperature:
- Estimate the date when 50% of overwintering adult flies have emerged based on the accumulation of 792 to 812 degree-days, with a developmental threshold of 39.2°F.
- Plant after the estimated date.

For onion maggot, take the following cultural measures in addition to delayed planting:
- Remove and dispose of onion culls and volunteer onions.
**Avoid planting successive onion crops without rotating to other crops.**

**Avoid planting onions near fields where onions were recently grown, or fields that are located near onion cull piles.**
- These fields most likely harbor overwintering onion maggot pupae.
- If possible, plant onions no less than 3/4 of a mile near fields that were previously planted to onion.

For seedcorn maggot, use degree-day accumulation to determine amount of time to delay planting after tilling or soil cultivation:
- **Assume that adult seedcorn maggot flies will begin laying eggs in the field immediately after the soil is disturbed.**
- **Estimate the date of the first adult emergence by tracking the accumulation of 421 to 459 degree-days Fahrenheit (with a developmental threshold of 39.0°F) after tillage.**

In the intermountain region, delaying planting 13 to 21 days after cultivation, tillage, or bed-shaping can reduce seedcorn maggot infestations. Soil conditions after tillage attract seedcorn maggot flies to lay eggs. Waiting at least 13 days will allow the first generation of seedcorn maggot to pupate and minimize their damage to onions. However, waiting as long as 21 days further reduces developmental time for onion bulbs, which may significantly reduce yields.

For seedcorn maggot, take the following measures in addition to delaying planting after disturbing the soil:
- **Avoid planting onions after a rotation of legume crops, especially alfalfa. Adult seedcorn maggot flies are especially attracted to these decaying residues.**
- **Plant seeds at a shallow depth (but no less than ½ inch below the soil surface).**
- **Thoroughly incorporate organic matter such as manure, crop residue, weeds, and cover crops into the soil well in advance of planting (3–4 weeks prior).**
  - In soils amended with animal manures, wait for the manure to break down completely before planting.

Cultural methods for both onion maggot and seedcorn maggot include the following:
- **Use a press wheel, chain drag or similar implement behind the drill to cover the seed row when planting.**
- **Plant in conditions that favor rapid onion emergence, such as when the soil is warmer. This will allow onions to quickly grow to a stage that is harder for maggots to damage.**
- **Avoid fields that have high amounts of undecomposed organic matter, such as fields just coming out of pasture, alfalfa, or recently tilled or cultivated weeds.**
- **For direct-seeded crops, use a higher seeding rate.**
- **Consider no-till seeding.**

**Monitoring and Treatment Decisions**
Monitor adult activity by placing yellow sticky traps around the field edges just above the growing onion foliage. Use degree-day models mentioned above in the Cultural Control section to determine when to plant.

Apply insecticides preventively, either in the form of seed treatment or an at-plant, in-furrow application. Consider an insecticide application especially for fields that are likely to be infested with maggots (see the Cultural Control section) or fields that have previously had problems from maggots.

The combination of cultural methods and well-timed insecticide application is critical to avoiding intolerable yield loss. There are no reliable pesticides that can be used in rescue applications once an infestation has been established.
Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Always read the label of the product being used.

### Seed Treatment

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount to use</th>
<th>REI‡</th>
<th>PHI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. SPINOSAD</strong>&lt;br&gt;(Regard SC)#</td>
<td>5.29–6.89 lb a.i./100 seed</td>
<td>4</td>
<td>NA</td>
</tr>
</tbody>
</table>
| MODE-OF-ACTION GROUP NUMBER: 5
| COMMENTS: This use is registered on dry bulb onion only. Contact your seed retailer for information and availability. |
| **B. SPINOSAD/THIAMETHOXAM**<br>(FarMore F1500) | Label rates | NA | NA |
| MODE-OF-ACTION GROUP NUMBER: 5/4A
| COMMENTS: **Farmore F1500 is not registered for use in California**, but seeds treated in and obtained from other states can be legally used in California, even for a chemical not registered for use on onion and garlic in California. This product also contains three fungicides. Contact your seed retailer for information and availability. |
| **C. CLOTHIANIDIN/IMIDACLOPRID**<br>(Sepresto 75WS) | Bulb onion: 0.0074–0.011 oz/1000 seed | NA | NA |
| | Bunching onion: 0.0056–0.0065 oz/1000 seed | | |
| | Leek: 0.0126 oz/1000 seed | | |
| MODE-OF-ACTION GROUP NUMBER: 4A/4A
| COMMENTS: Not registered for use in garlic. Avoid planting when pollinators are nearby; pesticide may become airborne. |

### At-Plant Application

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount to use</th>
<th>REI‡</th>
<th>PHI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. CHLORPYRIFOS</strong>&lt;br&gt;(Lorsban Advanced)</td>
<td>Label rates</td>
<td>24</td>
<td>60</td>
</tr>
</tbody>
</table>
| MODE-OF-ACTION GROUP NUMBER: 1B
| COMMENTS: Registered for use on dry bulb onions only. Incorporate into soil 1 to 2 inches. Do not make more than one application per year. Avoid drift and tailwater runoff into surface waters. Additional application restrictions may apply; for more information on current California permit restrictions, see the Department of Pesticide Regulation’s Chlorpyrifos Interim Recommended Permit Conditions. |
| . . . or . . .<br>(Lorsban 15G) | 3.7 oz/1000 row ft | 24 | NA |
| COMMENTS: For dry bulb onions only. Apply in-furrow. Do not make more than one application per year. Additional application restrictions may apply; for more information on current California permit restrictions, see the Department of Pesticide Regulation’s Chlorpyrifos Interim Recommended Permit Conditions. |
‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

# Acceptable for use in organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.

1 Rotate insecticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. Mode-of-action group numbers (un = unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee).

NA Not applicable
THRIPS (10/18)
Scientific Names: Onion thrips: *Thrips tabaci*
Western flower thrips: *Frankliniella occidentalis*

DESCRIPTION OF THE PESTS
Thrips are very small, slender insects that can be easily seen with a hand lens. Mature onion thrips are about 0.05 inch (1.3 mm) while western flower thrips are slightly larger at 0.06 inch (1.5 mm). The most distinctive characteristic of thrips is two pairs of wings that are fringed with long hairs. Adults are pale yellow to light brown. The immature stages have the same body shape as the adult stage, but unlike adults, they are wingless and lighter in color.

When viewed under a microscope, western flower thrips can be distinguished from onion thrips by the hairs on the front of the thorax (the body segment after the head), as well as their 8-segmented antennae. In contrast, onion thrips lack these hairs, and their antennae are 7-segmented. These structures are best seen through a compound microscope at 400x.

Thrips are the most common insect pest of onion, causing widespread damage. They are found wherever onions are grown in California. Thrips are present every year, but infestations vary widely depending on weather conditions. Both onion thrips and western flower thrips have a wide host range that includes cereal crops, broadleaved crops, and many weed species. Both onion thrips and western flower thrips attack onion, but onion thrips are believed to be more prevalent and injurious than western flower thrips. Many areas have both onion thrips and western flower thrips, and their numbers can vary over the season.

Thrips thrive in hot and dry conditions and are usually more damaging in areas where these climatic conditions prevail for most of the production season. They may also transmit *iris yellow spot virus*, which is only vectored by onion thrips.

DAMAGE
High numbers of thrips can reduce both yield and storage quality of onions. Onion thrips also can be an occasional problem on garlic but are generally not as serious a pest as they are on onion.

Thrips are most damaging when they feed during the early bulbing stage of onion development. They feed under the leaf folds and in the protected inner leaves near the bulb but may also be found feeding on exposed leaf surfaces when their numbers are high. Their feeding may lead to leaf scarring, which is most serious on green onions. Severe scarring can reduce the effective photosynthetic area and creates an entry point for foliar diseases.

Both adults and nymphs cause damage. When foliage is severely damaged, the entire field takes on a silvery appearance.

MANAGEMENT

Biological Control
Natural enemies, including predaceous mites, minute pirate bugs, and lacewings, are often found feeding on thrips. However, natural enemies are susceptible to broad-spectrum insecticide sprays such as pyrethroids, and may not be reliable or effective in fields where broad-spectrum insecticides have been used.

Cultural Control
Avoid planting onions near grain or alfalfa fields if possible, because thrips often increase in those fields in the spring and migrate to onion fields when the grain senesces, or when the alfalfa is cut. Overhead irrigation and rainfall suppress thrips numbers, but pesticide applications are often still necessary.
Organically Acceptable Methods
Use biological and cultural controls in an organically certified crop. Sprays of the Entrust formulation of spinosad, azadirachtin, and entomopathogenic fungi such as Beauveria bassiana are also acceptable for use on organically certified crops.

Monitoring and Treatment Decisions
Thrips are most damaging to yields during the early bulbing stage. However, management should start before onions reach the bulbing stage, so that they do not reach levels that are difficult or impossible to control. Onions can tolerate higher numbers of thrips closer to harvest. However, in the case of hand-topped onions, applying pesticide closer to harvest may also be desirable because thrips can be a nuisance to harvest crews.

Evaluate thrips numbers in a field by randomly sampling entire onion plants (see Identifying Pests of Onion and Garlic and Their Damage for thrips photos and identification tips):

- Sample at least five plants from four separate areas of the field.
- Pull the leaves apart.
- Use a hand lens to count all the thrips on the inner leaves near the bulb as well as those under the leaf folds.
- Use a hand-held click counter for more efficient counting. Thrips are highly mobile and may disperse or hide before they can be counted.
- Use the thrips monitoring form to record your results.

If you wish to make a cursory evaluation of thrips infestation, randomly sample leaves to evaluate thrips numbers and damage under leaf folds. Keep in mind that sampling only the leaves often fails to detect thrips hidden between leaves near the bulb.

An economic threshold has not yet been developed for thrips, but an action threshold of 30 thrips per plant mid-season (lower for very young plants and higher for larger, mature plants) has been used for making successful pesticide application decisions for dry bulb, fresh market, and drying onions. Other thresholds that use thrips per leaf (rather than thrips per plant) are used in New York and other states, in which all thrips are counted on a plant and then divided by the number of leaves. This method accounts for the size of the onion plant; however, the reliability of the method has not yet been evaluated in California.

Because the marketability of green onions (those marketed fresh with the leaves attached) is severely reduced by thrips scarring, apply insecticide at the first sign of thrips feeding. On onions grown for seed, thrips can reduce yield and quality of seed production during seed set, but no treatment thresholds have been established.

While resistance to organophosphate and pyrethroid insecticides has not been evaluated in California, it has been documented in other states and is suspected in California. For this reason, alternate insecticides with different modes of action when multiple pesticide applications are needed per season. A common practice for minimizing the risk of resistance development in thrips populations is to apply insecticides with the same mode of action for a maximum of two consecutive applications, and use an insecticide with a different mode of action to control the next generation of thrips if a third application is necessary. A total of three applications is often enough. Thorough coverage is essential for control, as most thrips feed in protected areas of the plant.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPIROTETRAMAT</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Always read the label of the product being used.

A. SPIROTETRAMAT
### Thrips

10/18

**Illustrated version at** [http://ipm.ucanr.edu/PMG/selectnewpest.onion-and-garlic.html](http://ipm.ucanr.edu/PMG/selectnewpest.onion-and-garlic.html)

<table>
<thead>
<tr>
<th>Mode of Action</th>
<th>Application Rate</th>
<th>Application Rate</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Movento</strong></td>
<td>5 fl oz</td>
<td>24</td>
<td>Garlic, bulb onion, bulb shallot: 3 Green onion, leek and shallot leaf: 7</td>
</tr>
<tr>
<td><strong>B. Spinetoram</strong></td>
<td>6–10 fl oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td><strong>C. Spinosad</strong></td>
<td>1.25–2.5 oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td><strong>D. Abamectin</strong></td>
<td>1.75–3.5 fl oz</td>
<td>12</td>
<td>Garlic, bulb onion, bulb shallot: 30 Leek, green onion, shallot leaf: 7</td>
</tr>
<tr>
<td><strong>E. Azadirachtin</strong></td>
<td>10–16 fl oz</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>F. Beauveria bassiana STRAIN GHA</strong></td>
<td>0.25–1 qt</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>G. Methomyl</strong></td>
<td>1 lb</td>
<td>48</td>
<td>7</td>
</tr>
<tr>
<td><strong>†</strong> Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>‡</strong> Permit required from county agricultural commissioner for purchase or use.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Acceptable for use on organically grown produce.

Rotate insecticides with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. Mode-of-action group numbers (un = unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee).
Diseases

BACTERIAL SOFT ROTS (1/07)
Pathogens: *Erwinia carotovora* ssp. *carotovora*, *Erwinia chrysanthemi*, *Pseudomonas gladioli*, and *Enterobacter cloacae*

SYMPTOMS
Bacterial soft rots are characterized by softening and water soaking of one or more of the inner fleshy scales of the bulb. Affected tissue is yellow initially, turning brown as the disease progresses lengthwise in the bulb. The neck of infected bulbs may be soft when pressed. These organisms generally appear just before or at the time of harvest or in storage.

COMMENTS ON THE DISEASES
Bacterial soft rots are primarily a problem on onions, but not garlic. Free water is essential for entry and spread of the bacteria. Wounds and senescent leaves are the means by which bacteria gain entrance into the bulb. The pathogens are soilborne and may be spread in irrigation water.

MANAGEMENT
Cultural Control
Avoid overhead irrigation once onions start to bulb (bulbing occurs about the time the bulb is twice the diameter of the neck). Harvest only after onion tops are well matured. Provide for quick drying following topping, especially if temperatures are high.

BASAL ROT (1/07)
Pathogen: *Fusarium oxysporum* f. sp. *ceae*

SYMPTOMS
Plants affected by basal rot show progressive yellowing and dieback from the tips of leaves. Affected roots are dark brown to dark pink. A white fungal growth is sometimes evident at the base of infected bulbs. When an infected bulb is cut vertically, a brown discoloration of the stem plate tissue is apparent. Later, the stem plate tissue becomes pitted and shows a dry rot. Under dry conditions, the stem plate and dry outer scales crack open. Basal rot can continue in storage.

COMMENTS ON THE DISEASE
The fungus survives indefinitely in soil. Infection occurs through wounds or in the vicinity of old root scars at the base of the bulb. The disease is favored by soil temperatures in the range of 57° to 90°F, with optimum temperatures being 79° to 82°F. Basal rot is more prevalent in transplanted onions than in direct-seeded onions.

MANAGEMENT
Cultural Control
Avoid fields with a history of basal rot problems and rotate 3 to 4 years out of onions, garlic, and leeks. Control soil insects and foliage diseases. Cure onions properly before storage. Store at cool temperatures since infection is favored by warm conditions.
BLACK MOLD (1/07)

Pathogen: *Aspergillus niger*

**SYMPTOMS**
Black mold occurs on both onions and garlic. The fungus is first evident at the top or sides of the bulb where disease or injury has caused an opening in the skin. The fungus develops between dry, dead outer scales and the first inner fleshy scales of the bulb. Invaded scales initially become water soaked. Under dry conditions diseased scales dry and shrivel, and black masses of spores are visible between outer scales. Diseased scales may also be invaded by soft rot bacteria, causing the whole bulb to deteriorate into a watery soft rot.

**COMMENTS ON THE DISEASE**
Black mold occurs most commonly where onions or garlic are grown under warm dry conditions such as the desert areas of California. It is more of a concern in onion crops than in garlic. The fungus survives on decaying organic matter such as plant debris.

**MANAGEMENT**
There are no chemicals for the direct control of black mold. Research indicates that a good fungicide control program for foliage diseases will reduce the incidence of black mold. Storage and transit temperatures below 55°F (12.8°C) and as low as 33°F (0.6°C) are recommended to suppress black mold development. Handling of bulbs to avoid bruising also reduces injury and invasion sites for the fungus.

BLUE MOLD ROT (6/08)

Pathogens: *Penicillium* spp.

**SYMPTOMS**
Blue mold generally appears during harvesting and storage. Initial symptoms include watersoaked areas on the outer surface of scales. Later, a green to blue green, powdery mold may develop on the surface of the lesions. Infected areas of fleshy scales are tan or gray when cut. In advanced stages, infected bulbs may disintegrate into a watery rot.

**COMMENTS ON THE DISEASE**
Many species of *Penicillium* can cause blue mold. These fungi are common saprophytes on plant debris and senescent plant tissue. Invasion of onion bulbs and garlic is usually through wounds, bruises, or uncured neck tissue. Once inside the bulb, the mycelium grows through the fleshy scales, eventually sporulating profusely on the surface of lesions and wounds. Optimum conditions include moderate temperatures 70° to 77°F (21° to 25°C) and high relative humidity.

**MANAGEMENT**
Avoid wounds and insect damage to bulbs. Harvest and handle onion bulbs with a minimum of bruising or wounding; most importantly, promptly cure the bulbs so the necks are dry. Store bulbs at temperatures of 41°F (5°C) or less with low relative humidity.
BOTRYTIS LEAFSPOT (6/16)

Pathogen: Botrytis cinerea

SYMPTOMS
Botrytis leafspot occurs on onions. White sunken spots on leaves are usually the first sign of infection; spots are small—0.06 inch (0.5 mm) up to 0.25 inch (6 mm) long—and tend to be oval. They sometimes have a light green halo and may appear water soaked. The epidermis around the spots may be silvery. When numerous spots are present, leaf tips die back and whole leaves may be killed.

COMMENTS ON THE DISEASE
Botrytis cinerea spores land on leaf surfaces and, in the presence of moisture, germinate and produce enzymes that kill leaf tissue. The fungus damages the leaf by causing leaf spotting. Leaf surfaces must be wet by dew or rain for long periods (20 or more hours) for leafspot to develop. Optimum temperature for germination of spores is 59°F; optimum temperature for mycelial growth is in the mid-70s (°F).

MANAGEMENT

Cultural Control
Isolate seed fields from fresh market or processing onion fields as bulbs are a major source of spore inoculum. To reduce the level of inoculum in the soil, use a 3-year rotation scheme away from Allium crops and destroy volunteer and cull onions during this period.

Chemical Control
Monitor fields and apply a treatment at the first evidence of leaf spotting.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount/Acre</th>
<th>REI‡</th>
<th>PHI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Example trade name)</td>
<td>(hours)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UPDATED 6/16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide’s properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. CHLOROTHALONIL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Bravo Weatherstik, Echo 720)</td>
<td>Label rates</td>
<td>12</td>
<td>Onion (Dry bulb) and Garlic: 7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): Multi-site contact (M5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: See label regarding special instructions related to the 12 hour REI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. MANCOZEB</td>
<td>2.4 qt</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>(Dithane F-45 37%F)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): Multi-site contact (M3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Registered for use on garlic, shallots, and bulb onions only. Do not apply more than 24 lb a.i./acre per crop.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment until the harvest may take place. In some cases the REI exceeds the PHI. The longer of these two intervals is the minimum time that must elapse before harvest may take place.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different group number.
BOTRYTIS NECK AND BULB ROT  (6/08)
Pathogen: Botrytis allii

SYMPTOMS
In onions, Botrytis bulb rot generally appears during storage, although infection originates in the field. Initial symptoms usually begin at the neck, where affected tissue softens, becomes watersoaked, and turns brown. In a humid atmosphere, a gray feltlike growth appears on rotting scales and mycelia may develop between scales. Sclerotia may eventually develop in the neck and sometimes between scales. In garlic, symptoms appear either in the field towards the end of the season or during storage. Plants infected in the field may be stunted with dead and dying outer leaves. Affected tissue is initially watersoaked but later turns dry and necrotic. Sclerotia form in the neck or adhere to the rotten outer scales of the bulb. In both onion and garlic, initial infections may be latent and symptoms develop only when leaves senesce and become necrotic.

COMMENTS ON THE DISEASE
Bulb rot affects garlic, onions, leek, and shallots. The fungus persists on dead onion and garlic tissue and for long periods as sclerotia in the soil. The sclerotia germinate in moist weather and produce airborne conidia, which land on tissue, germinate, and infect when conditions are favorable. The greatest incidence of infection occurs when cool 50° to 75°F (10° to 24°C) and moist weather prevail. The fungus is associated with garlic and onions wherever they are grown and is a common colonizer of senescent tissue.

MANAGEMENT
During the growing season, minimize damage to bulbs caused by insects and diseases. Avoid heavy or late applications of nitrogen fertilizer. Harvest onions and garlic only when the crop is mature and necks are well cured. Handle the crop with a minimum of bruising or wounding. Avoid late-season irrigation to allow the tissue to dry before harvest. The neck tissue must be well-cured before the crop is stored. Healthy onions that are properly stored are seldom affected. Store bulbs at temperatures of 41°F (5°C) or less with low relative humidity and good circulation.
DOWNY MILDEW (6/16)

Pathogen: *Peronospora destructor*

SYMPTOMS
Downy mildew can infect both onions and garlic. The first evidence of disease is a fine, furry, grayish white to purple growth on the surface of older leaves. Leaf tissue under the growth becomes pale green, then yellow, and finally collapses. Large, yellowish, circular clumps of infected plants, a few to many feet in diameter, may be the first symptom noticed in the field. The yellowing patterns often enlarge in the direction of prevailing winds.

COMMENTS ON THE DISEASE
Downy mildew can develop from an initial infection by airborne spores into an epidemic very quickly if humidity and temperature conditions (1.5 to 7 hours of leaf wetness and 43° to 80°F) are favorable. Spores can travel long distances in moist air, but are quickly killed by dry conditions. Initial sources of disease can be infected bulbs, sets, seeds, and plant debris.

MANAGEMENT
Cultural Control
Use disease-free bulbs, sets, and seed. Use a 3-year rotation away from *Allium* crops in fields where the disease has occurred. Destroy volunteer *Allium* plants in and around the field and buildings. Locate onion fields where there is good air movement to promote rapid drying of foliage. Currently there are a few red onion cultivars (e.g., Calred) that are resistant to downy mildew.

Chemical Control
Spray at the first sign of disease; fungicides may be applied on a 7-day schedule, if necessary. For all fungicides, thorough coverage of foliage is important in the control of downy mildew.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount/Acre (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPDATED 6/16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide’s properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. FENAMIDONE (Reason 500 SC)</td>
<td>5.5 fl oz 12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): Quinone outside inhibitor (11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply more than 22 fl oz/acre per season or make more than one application before alternating with a fungicide that has a different mode-of-action group number.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. MANCOZEB/MEFENOXAM (Ridomil Gold MZ WG)</td>
<td>2.5 lb 48</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): Multi-site contact (M3) and Phenylamides (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dithiocarbamate and Phenylamide (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Registered for use on garlic, bulb onions, and shallots (dry bulb). Do not apply to exposed bulb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. MEFENOXAM/CHLOROTHALONIL (Ridomil Gold Bravo SC)</td>
<td>2.5 lb 48</td>
<td></td>
</tr>
<tr>
<td>Bulb onions: 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green onions: 21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): Phenylamide (4) and Multi-site contact (M5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Registered for use on garlic, bulb onions, green onions, and shallots (dry bulb).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. DIMETHOMORPH (Forum)</td>
<td>6 fl oz 12</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): Carboxylic acid amides (40)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. CHLOROTHALONIL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Illustrated version at http://ipm.ucanr.edu/PMG/selectnewpest.onion-and-garlic.html
<table>
<thead>
<tr>
<th>(Bravo Weatherstik, Echo 720)</th>
<th>See label</th>
<th>12</th>
<th>Garlic, bulb onions: 7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Green onions, leeks, shallots: 14</td>
</tr>
</tbody>
</table>

**MODE-OF-ACTION GROUP NAME (NUMBER):** Multi-site contact (M5)

**COMMENTS:** See label regarding special instructions related to the 12 hour REI

### F. MANCOZEB

<table>
<thead>
<tr>
<th>MANCOZEB</th>
<th>Label rates</th>
<th>PHI</th>
<th>See label</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Penncozeb 75DF)</td>
<td>2–3 lb</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>(Dithane M45)</td>
<td>3 lb</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>(Dithane F-45 37%F)</td>
<td>2.4 qt</td>
<td>24</td>
<td>7</td>
</tr>
</tbody>
</table>

**MODE-OF-ACTION GROUP NAME (NUMBER):** Multi-site contact (M3)

**COMMENTS:** Registered for use on garlic, shallots, and bulb onions only. Do not apply to exposed bulb.

### G. COPPER#

<table>
<thead>
<tr>
<th>COPPER#</th>
<th>Label rates</th>
<th>PHI</th>
<th>See label</th>
</tr>
</thead>
</table>

**MODE-OF-ACTION GROUP NAME (NUMBER):** Multi-site contact (M1)

**COMMENTS:** Not as effective as other pesticides, but some products are acceptable for use in an organically certified crop.

† Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

‡ Acceptable for use on organically grown produce.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.
GARLIC MOSAIC  (1/07)
Pathogen: several viruses in the potyvirus group

SYMPTOMS
Symptoms of garlic mosaic include mild to strong mosaic, chlorotic mottling, striping, and streaking of leaves. Symptoms are usually more pronounced in young leaves. Infected plants are stunted and bulb size is reduced.

COMMENTS ON THE DISEASE
Because garlic is vegetatively propagated, several viruses are commonly present in all garlic. The label "garlic mosaic" has been applied to a number of different viruses in different countries and this has caused some confusion. However, there is a trend toward referring to garlic mosaic as a disease caused by one or more viruses belonging to the potyvirus group (onion yellow dwarf virus, leek yellow stripe virus, and several others). In addition to being spread by vegetative reproduction, these potyviruses can also be transmitted by various aphids.

MANAGEMENT
Virus-free stocks should be produced from meristem tip culture and multiplied in areas free of commercial garlic to prevent reinfection by insects. Use of such "virus-free" stock can result in substantially higher yield.

IRIS YELLOW SPOT  (6/09)
Pathogen: Iris yellow spot virus

SYMPTOMS
Symptoms of iris yellow spot on onion include yellow- to straw-colored lesions on leaves and scapes. Dry, elongated lesions or flecks may resemble thrips injury. Lesions may be diamond shaped (this occurs rarely on leaves, more commonly on scapes). Late in the season, infected seed stalks and leaves may lodge. Plant vigor and bulb size are reduced.

COMMENTS ON THE DISEASE
The pathogen is a tospovirus that is transmitted by onion thrips, *Thrips tabaci*. The virus infects most *Allium* species, although garlic is not thought to be a host. It also infects some ornamentals (iris, lisianthus) and some weeds (jimsonweed, tobacco, redroot pigweed). The highest disease incidence is typically near field edges. Otherwise healthy plants may show few symptoms and maintain decent growth, while stressed plants may be killed.

MANAGEMENT
Maintain good fertility and adequate soil moisture to reduce plant stress. Practice good sanitation, and remove and destroy infected plants along with cull piles. Eliminate weeds in and around onion fields, especially volunteer onions and wild alliums.

Chemical Control
Disease severity is related to thrips populations; controlling ONION THRIPS will help reduce incidence of this disease.
ONION YELLOW DWARF (1/07)
Pathogen: Onion yellow dwarf virus

SYMPTOMS
The first symptoms of onion yellow dwarf in young onions are yellow streaks at the bases of the first true leaves. All leaves developing after these initial symptoms show symptoms ranging from yellow streaks to complete yellowing of leaves. Leaves are sometimes crinkled and flattened and tend to fall over. Bulbs are undersized.

This virus is part of the virus complex that causes GARLIC MOSAIC.

COMMENTS ON THE DISEASE
The onion yellow dwarf virus is a potyvirus that has a narrow host range (onions, garlic, shallots and a few ornamental alliums). It survives in bulbs and sets and therefore can be transmitted during vegetative reproduction. Although the virus is not spread to the seed, seed from infected plants is of poor quality. It can survive in volunteer onions. It is spread from plant to plant by the green peach aphid, *Myzus persicae*, and other aphids in a nonpersistent manner.

MANAGEMENT
Controlling the aphids does not prevent the disease, because they quickly transmit the virus as they move through the crop in search of preferred hosts. Use true onion seed rather than sets. Use virus-free planting stock (in garlic, indexing for the virus and meristem tip culture eliminates the virus). Rogue infected plants.

There is no chemical control for this disease.
PINK ROOT (6/16)
Pathogen: Phoma terrestris

SYMPTOMS
The most striking symptom of pink root is, as the name indicates, pink roots. Infected roots first turn light pink, then darken through red and purple, shrivel, turn black, and die. The pinkish red discoloration may extend up into the scales of the bulb. New roots also may become infected. If infection continues, plants become stunted. The disease seldom results in plant death. Infection is confined to roots and outer scales of the bulb. Many weak Fusarium species can also cause pink roots, particularly on old roots; diagnosis of pink root can be accurately accomplished only on actively growing plants.

COMMENTS ON THE DISEASE
Pink root is primarily a problem on onion; garlic is infected by the pink root organism, but the disease rarely occurs at an economically important level. The fungus is a common soil inhabitant that penetrates onion roots directly; wounds are not necessary for infection, but weak plants are more susceptible. The pathogen can persist in soil indefinitely; the longer onions are grown in the field, the more destructive the disease becomes. The fungus can be spread in water and on dirty equipment. Optimum temperatures for disease development are 75° to 85°F.

MANAGEMENT
Prevention and control include avoiding repeated cropping of onion on the same soil, use of resistant varieties, good soil tilth and fertility, control of insects and other diseases to maintain healthy plants, and preplant soil fumigation. Because so many crops are hosts of the pathogen, rotation is not an effective control, but long-term rotations out of onion for 5 years or more are recommended because each crop of onions increases disease incidence. Planting onions after cereals can also be hazardous because the inoculum potential generally becomes greater with cereals than with onions.

Disease-resistant varieties are available, but many popular varieties do not have this characteristic; furthermore, many resistant varieties are resistant in some locations but not in others, depending on which strains of the fungus are present. Fumigation with metam sodium or chloropicrin can be effective against some strains of the fungus but is not effective against many of the more virulent strains. It is also not always economical unless a high value seed crop is being grown. Solarization has proven effective in areas like the San Joaquin Valley where onions are planted in fall after a summer fallow period.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount/Acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPDATED 6/16</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide’s properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. METAM SODIUM* (various products)  
   Label rates  
   See label  
   NA  
   COMMENTS: Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone

B. CHLOROPICRIN* (various products)  
   Label rates  
   See label  
   NA  
   COMMENTS: Preplant.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of the two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

NA Not applicable.
PURPLE BLOTCH AND STEMPHYLIUM LEAF BLIGHT  (6/16)

Pathogens: Purple blotch: *Alternaria porri*
Stemphylium leaf blight: *Stemphylium vesicarium*

SYMPTOMS
Purple blotch and Stemphylium leaf blight occur primarily on onions as oval-shaped tan and deep purple lesions on leaf blades. Yellow streaks, which turn brown, extend along the blade in both directions from the lesion. In advanced stages lesions may girdle and kill leaves and seed stems. Concentric zones may develop within the lesions.

COMMENTS ON THE DISEASES
Stemphylium leaf blight is more common than purple blotch in California, but symptoms are identical for both diseases and they are managed in the same manner. These diseases are favored by heavy dew in desert areas and by foggy and rainy weather in other regions; optimum temperature for disease development is in the mid-70s (°F). The spores are airborne. In California, these diseases are often associated with downy mildew lesions on onions; they occur less commonly on garlic. Infection of seed stalks can reduce seed yield and quality.

MANAGEMENT
Chemical Control
Treatment for downy mildew also controls purple blotch and Stemphylium leaf blight. These diseases are usually not a problem after the end of the rainy season except in the Imperial Valley where they can cause damage up to harvest under conditions of high humidity and heavy nighttime dew.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount/Acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
</table>
| **A. FENAMIDONE**  
(Reason 500 SC) | 5.5 fl oz | 12 | 7 |
| MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)  
COMMENTS: Do not apply more than 22 fl oz/acre per season or make more than one application before alternating with a fungicide that has a different mode-of-action group number. |
| **B. PYRACLOSTROBIN**  
(Cabrio EG) | 8–12 oz | 12 | 7 |
| MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)  
COMMENTS: Do not exceed 72 oz/acre per season or make more than two sequential applications before rotating to a fungicide with a different mode-of-action group number. |
| **C. CHLOROTHALONIL**  
(Bravo Weatherstik, Echo 720) | Label rates | 12 | 7 |
| MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M5)  
COMMENTS: See label regarding special instructions related to the 12 hour REI |
| **D. MANCOZEB**  
(Penccozeb 75DF) | 2–3 lb | 24 | 7 |
| (Dithane M45) | 3 lb | 24 | 7 |
| MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M3) |

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide’s properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.
COMMENTS: Do not apply more than 30 lb/acre per crop. For use on bulb onions, garlic, and shallots only; do not apply to exposed bulb.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.
RUST (6/16)

Pathogen: *Puccinia porri*

**SYMPTOMS**
Rust is primarily a disease of garlic, although onion, leeks, shallots, and wild species of *Allium* are hosts. Small, reddish to dull orange oval-shaped pustules develop on leaf blades. Reddish airborne urediospores are copiously produced within the lesions. Later in the growing season, the lesions may appear dark because black teliospores develop within the pustules. Heavily infected leaves turn yellow and may collapse prematurely. When infection is severe, bulb size and quality are reduced.

**COMMENTS ON THE DISEASE**
Rust is a sporadic disease that generally causes little or no economic damage. Since 1998, however, rust has caused severe damage in some garlic-growing areas. Apparently, the disease only damages onions when they are planted next to a heavily infected garlic field. The fungus probably overwinters on garlic and volunteer *Allium* crops.

**MANAGEMENT**
Rotate away from *Allium* crops for 2 to 3 years and destroy volunteer *Allium* plants during this period. Fungicides may be warranted if more than a few pustules develop on plants.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount/Acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. AZOXYSTROBIN (Quadris)</strong></td>
<td>6–12 fl oz</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER¹): Quinone outside inhibitor (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Begin applications before disease development and repeat every 7 to 14 days up to three applications.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. MANCOZEB (Penncozeb 75DF)</strong></td>
<td>2–3 lb</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER¹): Multi-site contact (M3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Applied as a protectant and in mixes, or used in rotation with systemic fungicides for disease resistance management.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. TEBUCONAZOLE (Orius 3.6F)</strong></td>
<td>Label rates</td>
<td>12</td>
<td>See label</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER¹): Demethylation inhibitor (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.
SOUR SKIN  (1/07)
Pathogen: *Pseudomonas (Burkholderia) cepacia*

**SYMPTOMS**
Individual leaves affected by sour skin wilt and die back. Internally, leaves develop a soft, watery rot. The fleshy scales associated with infected leaves rot to form a tan-colored slimy ring in the bulb. Adjacent rings may remain healthy. The neck of infected bulbs is soft when pressed.

**COMMENTS ON THE DISEASE**
Sour skin occurs on both onion and garlic, but usually is only a concern on onion. The pathogen, which survives in the soil, is splashed onto leaves and into the neck of the onion during rain or overhead irrigation. The bacteria gain entrance through wounds and watersoaked tissue. Once in a leaf, bacteria continue to grow down the blade into the bulb. Warm weather favors disease development; optimum temperatures for disease development are over 85°F.

**MANAGEMENT**
* Cultural Control
  Switch from sprinkler to furrow irrigation once onions start to bulb (bulbing occurs about the time the bulb is twice the diameter of the neck). Make sure onion tops are well matured before harvesting. Provide for quick drying following topping, especially if temperatures are high.
WHITE ROT (6/16)
Pathogen: *Sclerotium cepivorum*

SYMPTOMS
Leaves of plants infected with the white rot pathogen show yellowing, leaf dieback, and wilting. Leaf decay begins at the base, with older leaves being the first to collapse. A semi-watery decay of the bulb scales results. Roots also rot, and the plant can be easily pulled from the ground. Associated with the rot is a fluffy white growth, the fungal mycelium, which develops around the base of the bulb. As the disease progresses, the mycelium becomes more compacted, less conspicuous, with numerous small spherical black bodies (sclerotia) forming on this mycelial mat. These sclerotia, the resting bodies of the pathogen, are approximately the size of a pin head or poppy seed. Plants can become infected at any stage of growth, but in California, symptoms usually appear from mid-season to harvest.

COMMENTS ON THE DISEASE
The pathogen persists as small, dormant structures, called sclerotia, in soil. Sclerotia can survive for over 20 years, even in the absence of a host plant. Disease severity depends on sclerotia levels in the soil at planting. As few as one sclerotium per 10 kilograms of soil can initiate disease. Only one sclerotium per kilogram of soil can cause measurable disease loss, and 10 to 20 sclerotia per kilogram result in infection of essentially all plants.

Sclerotia can be spread throughout a field or from field to field by flood water, equipment, or on plant material, including wind blown scales. Sclerotia remain dormant in the absence of onion or other *Allium* crops. Their germination is stimulated by *Allium* root extracts and exudates that extend into the soil about 0.5 inch from the root.

Disease development is favored by cool, moist soil conditions. The soil temperature range for infection is 50° to 75°F, with optimum being 60° to 65°F. At soil temperatures above 78°F, the disease is markedly inhibited. Soil moisture conditions that are favorable for onion and garlic growth are also ideal for white rot development.

MANAGEMENT
The most effective controls for white rot are avoidance and sanitation. Once a field is infected, chemical treatments are necessary to produce onion or garlic crops.

Cultural Control
Do not move cull bulbs, litter, and soil from infested to noninfested fields. Always clean equipment before moving from one field to another. Onion seed is not likely to carry sclerotia, but transplants and sets can. On garlic, the disease is commonly introduced into the field on seed cloves. The most effective way to avoid introducing the disease this way is to plant only clean stock from known origins that have no history of white rot. However, the fungus is vulnerable at temperatures above 115°F, thus dipping seed garlic in hot water will greatly reduce the amount of pathogen and is a good preventative measure, although it may not completely eradicate the fungus. Also, temperatures above 120°F may kill the garlic, so careful temperature control is essential.

If disease is observed, cessation of irrigation will minimize damage but not stop the disease. In addition, follow a long-term rotation schedule and do not follow *Allium* crops with other *Allium* crops. Rotation alone will not control white rot because sclerotia can survive more than 20 years in soil, but it does help prevent buildup of the pathogen.

Organically Acceptable Methods
Cultural control.

Management Decisions
The white rot fungus produces no functional spores. Instead, it propagates only by the production of round, poppyseed-sized sclerotia produced on the roots of decayed host plants. The sclerotia germinate only in response to root exudation peculiar to the genus *Allium*. The specific reaction between sclerotia and exudates suggests a possible use of sclerotial germination stimulants for controlling white rot.
disease. If products containing the root exudates are applied to the ground in the absence of an *Allium* crop, the sclerotia may be “tricked” into germinating. In the absence of a host, the mycelium from germinating sclerotia persist for a few days to several weeks depending on the soil temperature, then die after exhausting nutrient reserves. Natural *Allium* products, or certain artificial products of petroleum cracking (e.g., diallyl disulfide) applied to the soil also stimulate sclerotia to germinate. In the absence of an *Allium* crop, these compounds result in high mortality of the fungus, which allows a subsequent successful onion or garlic crop. To use garlic extract, apply it at least one year after all *Allium* crops, including volunteer *Alliums*, have been removed from the field. The optimum conditions for germination of sclerotia occur when soil temperatures are between 59° to 64°F; this is also the best time to apply the garlic extract.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount/Acre</th>
<th>REI‡</th>
<th>PHI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Example trade name)</td>
<td>(hours)</td>
<td>(days)</td>
<td></td>
</tr>
<tr>
<td><strong>UPDATED 6/16</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not all registered pesticides are listed. <strong>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.</strong> When choosing a pesticide, consider information relating to the pesticide’s properties and application timing, honey bees, and environmental impact. <strong>Always read the label of the product being used.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. <strong>TEBUCONAZOLE</strong></td>
<td>20.5 fl oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>(Orius 3.6F)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: Demethylation Inhibitor (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply in 4- to 6-inch band over/into each furrow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. <strong>PENTHIOPYRAD</strong></td>
<td>See label</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>(Fontelis)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: Succinate dyhydrogenase inhibitor (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply in 4- to 6-inch band over/into each furrow. Use allowed under a Supplemental Label.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. <strong>FLUDIOXONIL</strong></td>
<td>7 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>(Cannonball WG)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: Phenylpyrroles (12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply in 4- to 6-inch band over/into each furrow. Use allowed under a Supplemental Label.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. <strong>BOSCALID</strong></td>
<td>6.8 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>(Endura)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: Succinate dyhydrogenase inhibitor (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply in 4- to 6-inch band over/into each furrow.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

§ Acceptable for use on organically grown produce.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.
Nematodes (1/18)

Scientific Names: Stem and bulb nematode: *Ditylenchus dipsaci*
Root-knot nematode: *Meloidogyne hapla, M. incognita, M. javanica, and M. chitwoodi*
Stubby root nematode: *Paratrichodorus* sp.

DESCRIPTION OF THE PESTS

Soil-dwelling nematodes are typically elongated, unsegmented, microscopic roundworms that occur in virtually every terrestrial environment. The vast majority of these species feed on microorganisms and microfauna without harming plants. They are an important part of the soil food web and nutrient cycling processes. In contrast, plant-parasitic nematodes feed on plants by puncturing and sucking the cell contents, and can considerably reduce crop yield and quality. Most plant-parasitic nematodes have hollow, needlelike mouthparts called stylets. The stylet enables the nematode to puncture plant cells and inject various compounds, which support the feeding process and may influence host physiology and morphology. A nematode life cycle typically includes an egg, four juvenile stages, and the adult stages. The length of the life cycle depends on the nematode species and the temperature of its environment.

Stem and Bulb Nematode
Stem and bulb nematodes live mostly within the plant, feeding on cells in stems, leaves, and bulbs. The species has many biological races with different host ranges. The race that infects onions and garlic requires mating to reproduce; a female lays 200 to 500 eggs within the host tissue. Optimal egg development occurs between 59˚ and 70˚F. The life cycle takes approximately three weeks at 59˚F. Both juveniles and adults are able to infect plants. Under moist, mild conditions (59˚ to 68˚F), stem and bulb nematodes can move in a thin water film on the plant surface to enter their host through stomates. Multiple generations can occur during one season, potentially resulting in a huge increase in nematode numbers. They are capable of surviving drought for many years in or on dry plant material, only to become active again with rehydration.

Root-Knot Nematode
Root-knot nematodes live primarily within the roots of their hosts. Only the second-stage juveniles are motile, while the other stages are sedentary. At least four root-knot nematode species may cause damage in onions and garlic.

Root-knot nematodes have a large host range and complete their life cycle in 3 to 4 weeks under optimal conditions. Juveniles hatch from eggs in their second stage. They are able to infect host roots at soil temperatures exceeding 41˚F (*M. chitwoodi*), between 55 to 57˚F (*M. hapla*), or between 59 to 64˚F (*M. incognita, and M. javanica*). After initial penetration, the nematodes move to a site near the vascular cylinder, where they establish a permanent feeding site. Once they have established this site, they become sedentary. After three further molts, the nematodes develop into slender, wormlike males that can leave the roots, or into pear-shaped females that stay at the feeding site.

Most root-knot nematode species can reproduce asexually, with the exception of *M. hapla*. The females lay several hundreds of eggs in a gel sack that provides protection against desiccation and predation.

Stubby Root Nematode
These nematodes live exclusively in the soil and feed on host roots. In contrast to the previously mentioned nematodes with hollow stylets, stubby root nematodes have a curved, solid spear that is used to puncture cells. The nematode secretes saliva from its mouth that hardens into a hollow tube, allowing the nematode to feed on cell contents. A new tube is formed each time the nematode moves to a new cell. Males are rare, as the stubby root nematode reproduces asexually.

Lesion Nematode
Lesion nematodes spend large proportions of their life history inside of hosts’ roots. These nematodes move through root tissues destructively while feeding on plant cells. When conditions become less suitable, they may leave the host to search for more suitable roots. While lesion nematodes have been shown to reduce growth and yield of onion and garlic crops in other states, they have not been reported to cause problems on onions or garlic in California.

SYMPTOMS AND DAMAGE
Field-level, aboveground symptoms of nematode problems often show as oval patches of stunted, thin plant stands. However, such symptoms may also be the result of other biotic and abiotic causes.

Stem and bulb nematodes can cause substantial crop damage and are of major concern in garlic and onion production worldwide. Migratory feeding by these nematodes creates cavities, leading to shortened, distorted or collapsing leaves and bloated tissues. The bulbs often soften at the neck. Cutting the bulb in half may reveal brown rings. Secondary invaders such as bacteria, fungi, and onion maggots may then cause soft rot and greatly accelerate the decay of the bulbs. Even during bulb storage at low temperatures, the nematodes may continue to develop, reproduce, and typically in combination with microbial contamination, damage the bulbs during storage.

Root-knot nematodes can also cause stunting and uneven stands of plants. The feeding process induces the characteristic knots or galls on the host’s roots. Their size depends on the nematode species and the response of the host. Gall formation by root-knot nematodes impedes the uptake of nutrients and water that may lead to stunted growth. Nutrients produced by photosynthesis are diverted to sustain the nematodes instead of supporting plant growth. The feeding process also lowers the host’s resistance to biotic and abiotic stress, such as the ability to deal with drought or microbial infections.

Stubby root nematodes feed primarily on the root tips of their host, which damages the meristematic tissues (growing root tissues). It causes the roots to remain very short. This impedes the ability of the host to take up nutrients and water, which reduces growth and bulb size.

Plants with lesion nematodes typically have fewer roots than noninfested plants, and may exhibit elongated, brown-to-black lesions along the roots.

FIELD EVALUATION
Because nematodes are tiny, colorless, and transparent, they are not easy to detect or identify. To make appropriate management decisions, it is critical to accurately diagnose the nematode species present and know how numerous they are. If a previous crop in the particular field had problems from nematodes that are also listed as pests of onions or garlic, their numbers may be high enough to damage sensitive young seedlings.

If nematode species in the field of interest have not previously been identified, consider taking soil samples and sending them to a diagnostic laboratory for identification.

1. Divide the field into sampling blocks measuring between 5 and 20 acres each. Each block should have similar cropping history, soil texture, or history of recent crop injury throughout.
2. Collect several subsamples randomly from a block, and mix them thoroughly to make a composite sample for laboratory analysis, which should be about 1 pint of soil for each block. Use soil from within the root zone (approximately 2 to 14 inches deep) and include samples of suspect plants.
3. Place samples from each block in separate plastic bags, seal them, and place a label on the outside with your name, address, location, and the current/previous crop and the crop you intend to grow.
4. Remove the samples from direct sun exposure, keep them cool (do not freeze), and transport as soon as possible to a diagnostic laboratory.
Contact your local cooperative extension advisor for more details about sampling, laboratories that identify nematodes in soil samples, and how to interpret sample results.

**MANAGEMENT**

**Cultural Practices**
Determine the cropping history of fields to be planted with seed garlic, onion transplants, or onion sets. The host range of the onion and garlic race of *D. dipsaci* (stem and bulb nematode) includes chives, leeks, certain lettuce cultivars, celery, hairy nightshade, and others. Growing nonhost and poor host crops such as corn in weed-free fields for at least three years will help reduce stem and bulb nematodes. However, such crops might be good hosts for other plant-parasitic nematodes.

Always use clean, noninfested cloves when planting garlic. Private laboratories or the California Department of Food and Agriculture can test garlic cloves to determine if they are infested with plant-parasitic nematodes.

Avoid infesting new fields by thoroughly cleaning machinery and equipment with water. Nematodes do not move far on their own; they are distributed mainly through infected planting material, irrigation or surface runoff water, contaminated equipment, and spread of infested soil.

There are currently no available onion or garlic cultivars with resistance to any nematode species.

**Treatment Decisions**
If noninfested seeds are not available, treating bulbs with hot water has been shown to reduce stem and bulb nematodes in garlic cloves. However, hot water treatment is unlikely to be 100% effective and may also predispose plants to other diseases.

Preplant fumigation can effectively reduce plant-parasitic nematode infestations in onion fields.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount Per Acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PREPLANT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. 1,3-DICHLOROPROPENE*/CHLOROPICRIN* (Inline)</td>
<td>Label rates</td>
<td>See label</td>
<td>NA</td>
</tr>
<tr>
<td>COMMENTS: This product is a soil fumigant used for preplant treatment of soil to control plant parasitic nematodes, symphylans, and certain weeds as well as to mitigate the impact of various soilborne fungal pathogens using low volume (drip) irrigation systems only. The use of a tarp seal is mandatory for all applications of this product to vegetable fields. Soil fumigants such as this product are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone. Its use amounts are restricted on a township basis.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. 1,3-DICHLOROPROPENE* (Telone EC)</td>
<td>Label rates</td>
<td>120 (5 days)</td>
<td>NA</td>
</tr>
<tr>
<td>COMMENTS: Fumigants such as 1,3-dichloropropene are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone. Use of a tarp seal is mandatory for all applications to vegetables in California</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. METAM SODIUM* (Vapam HL)</td>
<td>Label rates</td>
<td>See label</td>
<td>NA</td>
</tr>
</tbody>
</table>

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide’s properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.
COMMENTS: Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

D. METAM POTASSIUM*  
(K-Pam HL)  
Label rates  
See label  
NA  
COMMENTS: Fumigants such as metam potassium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

PLANTING OR AFTER

A. OXAMYL  
(Vydate L)*  
Label rates  
48  
See label  
COMMENTS: Can be applied in-furrow, as a band, or in sprinkler or furrow irrigation. In-furrow and band applications must be followed by irrigation. See label for additional information. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

NA Not applicable.
Weeds

INTEGRATED WEED MANAGEMENT (10/18)

An integrated weed management program is essential for onion and garlic production because of the unique challenges posed by their planting densities and susceptibility to weed competition. These crops are slow-growing and shallow-rooted, planted at high densities, and susceptible to severe yield loss from weed competition. Their narrow, upright leaves do not compete well with weeds, and their long growing season allows for successive flushes of weeds. Weed control is often challenging in these crops because few herbicides are registered, mechanical cultivation is often limited in high-density plantings, and handweeding can be costly. A good integrated weed management plan can increase the ease and effectiveness of these management tactics.

Planting densities for onion and garlic pose unique challenges to weed management. These crops are sown at high plant densities and are not thinned to produce the greatest possible yield per acre. Onions are planted with 4 to 10 seed lines on beds that are 40 to 80 inches wide (furrow to furrow), or 36 inches wide in the intermountain area. Garlic is typically planted with 2 to 4 seed lines on 40-inch beds. These planting configurations limit cultivation to the furrow and narrow row middles on the bed top.

Emphasis must be placed on techniques that reduce weed pressure before planting, such as the use of the stale seedbed method, weed-free seed, or soil solarization. Any method that reduces the amount of weed seed in the soil will reduce weeding costs during crop production. Another good way to prevent weed problems is to control existing weeds before they go to seed.

MONITORING

Monitor the fields and keep records of the weed species present in each field during the growing season. Pay special attention to weeds likely to be present at planting time. Not only are these records valuable in choosing the most suitable fields for growing onions and garlic, they also help track the occurrence of hard-to-control weeds.

Plant onion and garlic in the most weed-free fields available, and avoid fields with high amounts of difficult-to-control perennial weeds such as nutsedge, field bindweed, bermudagrass, johnsongrass, clovers, and Canada thistle. If weedy fields must be used, control weeds during fallow periods using stale seedbeds and herbicide application or shallow tillage. Fumigation with metam potassium or metam sodium can also be used to reduce the weed seed bank.

WEED MANAGEMENT BEFORE PLANTING

Nonchemical control options are primarily limited to the preplant period in onion and garlic production. For most weed control methods, timing is important because small weed seedlings are easier to kill than larger weeds.

Crop Rotation With Cover Crops

Cover crops are rarely used in onion and garlic production. However, they can provide a variety of benefits to the crop when used in crop rotations, especially if they are grown in the fall prior to planting Alliums.

Timing is the key to whether cover crops promote or inhibit weed growth. If cover crops become established quickly, they will suppress weeds. Adequate seeding rate of the cover crop is also an important factor in providing rapid ground cover and suppressing weeds. Vigorous cover crops that provide complete ground cover in the first 30 days of the cover crop cycle are very competitive with weeds and greatly limit weed growth. Competitive species include cereal rye (Secale cereale), white mustard (Sinapis alba), and Indian mustard (Brassica juncea). Avoid slow-growing winter cover crops, including legumes and many cereal-legume mixes, which allow substantial weed growth and set seed early in the growth cycle of the cover crop. Cover crop residues must have adequate time (at least 3 to 4 weeks) to break down in the soil before planting onion and garlic, which require shallow, precise seeding depth with good seed-to-soil contact.
Cover crop residues can increase pressure from certain diseases and insect pests. For example, cover crops can increase seedcorn maggot numbers. If a cover crop is used, incorporate the cover crop three to four weeks before planting onion or garlic to avoid tilling in green residues that attract this pest.

Cover crops also have the potential to increase weed pressure for the following reasons.

- Annual weeds frequently establish themselves at the time of the cover crop.
- Depending upon the species, weeds can grow in the cover crop and set seed unnoticed.
- Weeds often decompose before the end of the cover crop cycle, making their detection difficult. In such cases, the cover crops act as nurse crops to weeds, making substantial contribution to the weed seed bank.

It is important to monitor your cover crops, particularly in the first 40 days following seeding, to make sure that they are not creating a weed problem for subsequent plantings of onion and garlic.

**Soil Solarization**

Soil solarization traps the sun's heat beneath a layer of clear plastic and disinfests the soil with higher temperatures that kill weed seeds, vegetative structures, insects, and some disease-causing pathogens (such as the fungus that causes pink root).

Solarization effectively controls seedlings (but not mature plants) of bermudagrass, johnsongrass, and field bindweed, and is more effective on annual weeds than perennial weeds. It partially controls yellow nutsedge, but does not control purple nutsedge. Annual weeds with a harder seed coat such as little mallow and velvetleaf are often hard to kill with solarization.

Plan to solarize soil according to planting time: plastic must remain in place for a minimum of 4 weeks, and the best results occur when the crop is planted immediately after removing the plastic. For some crops, growers burn holes into the plastic mulch and transplant directly into them; however, this practice may be of limited value for high-density plantings of onion and garlic.

Because solarization requires a summer fallow, it works best with a fall-planted crop. In the desert and Central Valley, the plastic should be in place during June through August, and can remain in place until planting begins in the fall.

Solarization may not be practical in areas with short growing seasons, or in coastal areas, where it does not heat the soil as deep. In coastal areas, apply plastic in fall when there is less chance of fog (i.e., August and September). Cultivate solarized soil less than 3 inches deep to avoid bringing viable weed seeds to the surface, where they germinate.

For more details on how to effectively solarize soil, see *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds*, UC ANR Publication 21377.

**Flaming**

Flaming can be used to kill or suppress the flush of weeds anytime between seeding the crop and its emergence. This technique is particularly effective on crops that have slow seed germination like onion, where nonprimed seed is used. Timing is critical: flaming must occur just prior to the emergence of the onion plants, when a good number of weeds are emerged. Flaming is more effective on small (i.e., less than two true leaves) broadleaves than on grass weed species.

Propane-fueled flamers are the most common type of flamer used for this method. Other equipment without an open flame includes hot water or steam applicators and infrared devices. Flamers can be handheld or mounted on a handcart or tractor. Mechanized flamers have multiple burners, while small devices typically have a single flame source.

Typically, flaming can be done at 3 to 5 miles per hour through fields, although this depends on the heat output of the unit being used. Briefly touch the basal stem area with the tip of the flame to disrupt the cells; do not flame weeds to the point where they char and burn. Best results occur under windless
conditions, as winds can prevent the heat from reaching the target. Early morning or evening are the best times to observe the flame for adjustment.

Determine the correct working pace or travel speed by checking weeds after flaming a test area. Weeds are being killed if gently pressing their leaves between your thumb and index finger creates a water-soaked appearance, indicating that cell membranes have ruptured. Plants may wilt, change color, or appear unaffected soon after flaming. Even if no change in the weeds is evident immediately, proper flaming causes plants to yellow and die within several days.

Fire is a serious hazard when flaming weeds. Only an experienced operator with demonstrated skill and good judgment should be allowed to flame weeds. Wet conditions during the rainy season or after a thorough irrigation are often good times to flame. Work in the early morning or late evening when winds are lower and any open flame is more visible. Proper flaming should not create smoldering vegetation or air pollution other than fuel burning emissions.

Use good judgment to identify hazardous situations in which flaming should not be conducted due to the risk of starting a fire. Do not use flame weeder in dry areas or during the dry season. Be especially cautious around mulch and leaf litter. Keep fire suppression equipment (e.g., a fire extinguisher, shovel, water) handy in case of an accident.

Cultivation
To prevent the increase of weed seed in the soil, cultivate weeds before they set seed in cover or rotation crops. After incorporation of the cover crop (if a cover crop is used), clean cultivate the field before planting onions or garlic.

Deep Plowing
Deep plowing is a tillage technique that buries weed seed or propagules of perennial plants below the depth at which they can germinate. The viability of buried weed seed declines over time. A relatively long interval (3–5 years) is preferred between deep plowing and subsequent deep plowing, to avoid bringing up large numbers of viable weed seed back to the soil surface. In fields heavily infested with nutsedge, plow fields with a specialized moldboard plow that fully inverts the soil, to bury tubers 10 to 12 inches. This can reduce up to 95 to 98% of nutsedge in the field.

Stale Seedbeds
This method can provide substantial weed control. It involves controlling the final flush of weeds before planting, followed by minimal soil disturbance to reduce subsequent weed flushes. To do this, prepare a seedbed and preirrigate it to germinate weed seeds. Cultivate as shallow as possible to kill emerged seedlings and prevent bringing up weed seed from deeper soil layers. Other options for killing the flush of weeds include flaming and foliar herbicides. The crop can then be planted on these beds soon afterward. If an herbicide is used, be sure to follow label directions on plantback restrictions.

The time of year and the irrigation system used may also affect the efficacy of this technique. Irrigate and cultivate as close as possible to planting time to ensure that soil temperature and climatic conditions are similar to the crop germination period, and to maximize weed control. If the interval between irrigation-cultivation and planting is too long, the weed spectrum (seasonal variation in weed species) may change due to changes in season or weather. Using shallow tillage 14 days after irrigation can reduce up to 50% of weeds in the subsequent crop.

Herbicides
Herbicides, combined with good cultural practices, control most weed pests of onion and garlic. There are specific herbicides that are applied before planting or after planting.

Herbicide selection depends upon the weed species that are expected to occur. Plantback restrictions need to be considered when selecting herbicides—herbicide residues in soil can limit the growth of sensitive rotational crops. Herbicide labels are the best source of information on plantback restrictions.

Preplant treatments are used in fields with persistent perennial weed problems. Metam sodium will destroy most weeds present. Paraquat and glyphosate can be used before the crop is planted to control
emerged weeds. Glyphosate has been particularly helpful in controlling perennial weeds the season before planting.

Organically Acceptable Methods
Use the above-mentioned nonherbicidal methods in an organically certified crop. The stale seedbed method and cultivation are especially important preplant weed management tactics in organic onions and garlic.

WEED MANAGEMENT AFTER PLANTING

Cultivation
Cultivation is one of the most effective postplant cultural weed control practices. Because of the high-density plantings of onions and garlic where most of the bed top is occupied with the seedlings, cultivation is often limited to a narrow band on the bed and the shoulders of the bed and furrows. Not all planting configurations of onions allow for bedtop cultivation, but the middle of the bed can be cultivated in garlic production.

The goal of cultivation is to remove weed seedlings as close to the seed row as possible without disturbing the crop. Precision guidance systems for cultivation (e.g. EcoDan®) can help improve the accuracy of cultivation operations. More precise cultivation allows for reducing the width of the uncultivated band, thereby removing a higher percentage of the weeds. Uncontrolled weeds in the seed line can be removed by postemergence herbicides or by handweeding.

Handweeding
Handweeding, although effective, is costly. Handweeding is particularly difficult in onion due to close plant spacing and the placement of multiple seed lines in a single bed. Handweed carefully to avoid damaging or killing onion plants, especially those that are young. Preventive measures, precision cultivation, and herbicides can also make handweeding less time-consuming and more effective.

Flaming
Flaming can be used to kill the flush of weeds any time between seeding the crop and its emergence. This technique is particularly effective on crops that have slow seed germination. However, its use in onions is limited if the onions germinate too quickly. This is particularly true in fields where primed seed is used.

Herbicides
Foliar-applied herbicides may be used after crop emergence to control established weeds. Layby herbicides are applied to clean-cultivated soil, typically at the 4- to 5-leaf stage of crop development, to keep the crop weed-free until harvest. Most fields require one or more postplant preemergence applications and one layby application. Split applications are most common for controlling weeds throughout the season, and to prevent unacceptable crop injury from herbicides.

Herbicide application sequences in onion and garlic typically involve applying preemergence herbicides to control or slow the growth of weeds germinating shortly after planting, and applying postemergence herbicides during the 1- to 5-leaf stage to control any weeds that escape preemergence treatments. Layby herbicides can help prevent weed flushes after cultivation or weeds that tend to germinate later in the growing season.

Preemergence herbicides
Preemergence herbicides typically require activation through irrigation. In both onion and garlic, DCPA, bensulide, ethofumesate, and pendimethalin can be used preemergence. However, preemergence use of pendimethalin is only registered for some areas and crops as directed by special labeling (see the Herbicide Treatment Table for more information regarding use at 75% radical emergence and the loop stage). In garlic, the above-mentioned materials can be used, as well as flumioxazin and oxyfluorfen. Pendimethalin controls many annual grasses and broadleaf weeds, and provides optimal weed control through sprinkler irrigation. In the southern San Joaquin Valley, a common practice is to combine application of flumioxazin or oxyfluorfen with pendimethalin to control weeds after planting garlic.
DCPA may be applied to bulb onions before or at seeding or transplanting, before weeds emerge. DCPA suppresses weeds and delays their growth, giving the crop time to mature. Later, when postemergence herbicides can be used, weeds are small and easier to control, whereas the crop has become large enough to withstand the herbicide application.

In both onion and garlic, occasionally postplant applications of glyphosate or paraquat are used to control germinated weeds before the crop emerges. The timing of this application is critical, because any emerged crop plants will be killed if contacted by these herbicides. If applied at more than 1% crop emergence, glyphosate may reduce the stand.

**Postemergence herbicides**

Several herbicides, including grass-selective herbicides, are available for postemergence use in both onion and garlic. Clethodim controls annual bluegrass, whereas other herbicides do not. See the Herbicide Treatment Table for more information.

Oxyfluorfen and bromoxynil can only be used on young onions (see the Herbicide Treatment Table for additional information). Oxyfluorfen is complimentary to bromoxynil in onion; together they control a wider spectrum of weeds than either do alone. They are usually used in sequence about 1 week apart depending on the crop growth rate and weeds present, and the order in which they are applied may vary according to experience. They can also be tank-mixed, or the sequence strategy can be combined with the tank mix method. If tank mixing these two chemicals, use a sufficient spray volume per acre and closely follow the label to avoid crop injury. Oxyfluorfen is commonly used when the crop has 1.5 fully developed true leaves, followed by an application of both oxyfluorfen and bromoxynil at the 2- and 3-leaf stages.

Ethofumesate can provide control of a variety of broadleaf and grass weeds. Dimethenamid controls yellow nutsedge if applied before nutsedge emerges.

**Organically Acceptable Methods**

After planting, use cultivation, flaming, and handweeding in an organically certified crop.

**LAYBY**

**Cultivation**

Cultivation will remove weeds from the furrow and sides of the bed. In the intermountain region, cultivate weeds between the 4- to 6-leaf stage. When drying out the field out for cultivation, avoid causing water stress to the crop. Take care to avoid injury to the root system on outside seed lines while cultivating.

Cultivation during the layby period can sometimes stimulate new flushes of weed species such as pigweed.

**Herbicides**

DCPA and pendimethalin are registered for use during the layby period in onion. Pendimethalin is available for layby use in garlic. These herbicides may be applied over the top of the crop and activated with irrigation. They do not control emerged weeds, and are used after cultivation of furrows. Some carryover can occur under certain conditions, creating a plantback problem. Consult the herbicide label before application.

**Organically Acceptable Methods**

During the layby period, use cultivation and handweeding in an organically certified crop.

**PREHARVEST**

Late-season weeds can be a problem in onion and garlic fields in the Central Valley, so it may be necessary to impose preharvest weed management efforts. Problematic weeds during this period include nightshade, nutsedge, and field bindweed. Weed growth during this time can increase the relative humidity within the field, increasing the risk of bulb rot. Harvest efficiency can also be...
hindered as weeds become entangled in the topping and harvest equipment, particularly with field bindweed.

If tall annual weeds (like nightshade) occur in patches in the field, using hand knives to sever the shoot from the roots can be effective. Controlled weeds should be layed in the furrow bottoms or removed from the field so they do not interfere with topping and harvest equipment.

When the weed infestation is widespread across the field, it is more efficient to apply glyphosate as a preharvest aid application. This is effective at drying down weeds like nightshade, nutsedge, and field bindweed, and allows for improved harvest of the crop. Application of glyphosate as a preharvest aid is available for onion and garlic grown for processing under a Special Local Needs [Section 24(c)] registration (see the Herbicide Treatment Table for more information).
SPECIAL WEED PROBLEMS (10/18)

YELLOW SWEETCLOVER AND WHITE SWEETCLOVER
Yellow sweetclover and white sweetclover are usually biennial but are occasionally summer annual or short-lived perennial weeds. They are difficult to control in onion and garlic because none of the registered herbicides will control them. Avoid growing onion or garlic crops in fields known to be heavily infested with these weeds.

NUTSEDGE
Yellow and purple nutsedge are perennial weeds that reproduce from underground tubers, which can survive for several years in the soil. Each tuber contains several buds that are capable of producing plants. Although only one bud germinates at a time to form a new plant, a new bud is activated if a germinated bud or plant is destroyed by cultivation or an herbicide. To best achieve control of nutsedge, use continuous cultivation during a summer fallow period, or rotate to crops where effective herbicide and cultural control methods can be used. Deep plowing with specialized moldboard plows will bury tubers 10 to 12 inches and can significantly reduce nutsedge numbers. Dimethenamid provides partial control of nutsedge if applied before its emergence. Fumigation with metam products does not control purple nutsedge and only partially controls yellow nutsedge.

ANNUAL BLUEGRASS
Annual bluegrass is mainly problematic in organic onion and garlic production. This weed can reach very high numbers in a field and become difficult to control, as cultivation and organic herbicides do not control it. While this weed was previously a problem in conventional production in the lower Colorado Desert, it has become less of an issue because clethodim controls it. In organic systems, management tactics include frequent handweeding or cultivation, preventing the weed from producing seed, using mulches that are several inches thick, and cleaning equipment before moving from infested fields to uninfested fields to prevent new infestations.

DODDER
Dodder is a parasitic weed that can build up in onion fields in the San Joaquin Valley and coastal valley growing areas. Avoid fields with a known history of this weed. DCPA (onion) and pendimethalin (onion and garlic) suppress or control this weed.

GREATER SWINECRESS
Greater swinecress is a winter or summer annual, and sometimes biennial, broadleaf weed. It is a major problem in onion and garlic production in the low desert. Most herbicides registered for onion and garlic do not control swinecress especially in the Imperial Valley. Bromoxynil partially controls swinecress.

LITTLESEED CANARYGRASS
Littleseed canarygrass is a winter annual grass weed has become more of a problem in the low desert in recent years. It has become resistant to many herbicides that are selective to grasses, including clethodim and fluazifop. Napropamide, pendimethalin, and glyphosate control canarygrass. Canarygrass can also be managed by rotating to a crop (such as broccoli) for which other registered herbicides (such as trifluralin) are effective options.
# COMMON AND SCIENTIFIC NAMES OF WEEDS

(10/18)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>barley, hare</td>
<td><em>Hordeum murinum</em> ssp. <em>leporinum</em></td>
</tr>
<tr>
<td>barnyardgrass</td>
<td><em>Echinochloa crus-galli</em></td>
</tr>
<tr>
<td>bermudagrass</td>
<td><em>Cynodon dactylon</em></td>
</tr>
<tr>
<td>bindweed, field</td>
<td><em>Convolvulus arvensis</em></td>
</tr>
<tr>
<td>bluegrass, annual</td>
<td><em>Poa annua</em></td>
</tr>
<tr>
<td>burclover, California</td>
<td><em>Medicago polymorpha</em></td>
</tr>
<tr>
<td>canarygrass</td>
<td><em>Phalaris minor</em></td>
</tr>
<tr>
<td>chickweed, common</td>
<td><em>Stellaria media</em></td>
</tr>
<tr>
<td>crabgrasses</td>
<td><em>Digitaria</em> ssp.</td>
</tr>
<tr>
<td>cudweeds</td>
<td><em>Gnaphalium</em> ssp.</td>
</tr>
<tr>
<td>docks</td>
<td><em>Rumex</em> ssp.</td>
</tr>
<tr>
<td>dodders</td>
<td><em>Cuscuta</em> ssp.</td>
</tr>
<tr>
<td>fiddleneck</td>
<td><em>Amsinckia</em> ssp.</td>
</tr>
<tr>
<td>filarees</td>
<td><em>Erodium</em> ssp.</td>
</tr>
<tr>
<td>fleabane, hairy</td>
<td><em>Conyza bonariensis</em></td>
</tr>
<tr>
<td>foxtails</td>
<td><em>Setaria</em> ssp.</td>
</tr>
<tr>
<td>goosefoot</td>
<td><em>Chenopodium</em> ssp.</td>
</tr>
<tr>
<td>groundcherrys</td>
<td><em>Physalis</em> ssp.</td>
</tr>
<tr>
<td>groundsels</td>
<td><em>Senecio</em> ssp.</td>
</tr>
<tr>
<td>henbit</td>
<td><em>Lamium amplexicaule</em></td>
</tr>
<tr>
<td>horseweed</td>
<td><em>Conyza canadensis</em></td>
</tr>
<tr>
<td>johnsongrass</td>
<td><em>Sorghum halepense</em></td>
</tr>
<tr>
<td>knotweed, common</td>
<td><em>Polygonum arenastrum</em></td>
</tr>
<tr>
<td>kochia</td>
<td><em>Kochia scoparia</em></td>
</tr>
<tr>
<td>lambquarters, common</td>
<td><em>Chenopodium album</em></td>
</tr>
<tr>
<td>lettuce, prickly</td>
<td><em>Lactuca serriola</em></td>
</tr>
<tr>
<td>lovegrasses</td>
<td><em>Eragrostis</em> ssp.</td>
</tr>
<tr>
<td>mallow, little (cheeseweed)</td>
<td><em>Malva parviflora</em></td>
</tr>
<tr>
<td>morningglories</td>
<td><em>Ipomoea</em> ssp.</td>
</tr>
<tr>
<td>mustards</td>
<td><em>Brassica</em> ssp.</td>
</tr>
<tr>
<td>nettles</td>
<td><em>Urtica</em> ssp.</td>
</tr>
<tr>
<td>nightshade, black</td>
<td><em>Solanum nigrum</em></td>
</tr>
<tr>
<td>nightshade, hairy</td>
<td><em>Solanum sarrachoides</em></td>
</tr>
<tr>
<td>nutsedge, purple</td>
<td><em>Cyperus rotundus</em></td>
</tr>
<tr>
<td>nutsedge, yellow</td>
<td><em>Cyperus esculentus</em></td>
</tr>
<tr>
<td>oat, wild</td>
<td><em>Avena fatua</em></td>
</tr>
<tr>
<td>panicum, fall</td>
<td><em>Panicum dichotomiflorum</em></td>
</tr>
<tr>
<td>pigweeds</td>
<td><em>Amaranthus</em> ssp.</td>
</tr>
<tr>
<td>puncturevine</td>
<td><em>Tribulus terestris</em></td>
</tr>
<tr>
<td>purslane, common</td>
<td><em>Portulaca oleracea</em></td>
</tr>
<tr>
<td>radish, wild</td>
<td><em>Raphanus raphanistrum</em></td>
</tr>
<tr>
<td>rocket, London</td>
<td><em>Sisymbrium</em> irr*</td>
</tr>
<tr>
<td>ryegrasses</td>
<td><em>Lolium</em> ssp.</td>
</tr>
<tr>
<td>shepherd’s-purse</td>
<td><em>Capsella bursa-pastoris</em></td>
</tr>
<tr>
<td>sowthistles</td>
<td><em>Sonchus</em> ssp.</td>
</tr>
<tr>
<td>sunflowers</td>
<td><em>Helianthus</em> ssp.</td>
</tr>
<tr>
<td>sweetclovers</td>
<td><em>Mellilotus</em> ssp.</td>
</tr>
<tr>
<td>swinecress, greater</td>
<td><em>Lepidium coronopis</em></td>
</tr>
<tr>
<td>thistle, Canada</td>
<td><em>Cirsium arvense</em></td>
</tr>
<tr>
<td>thistle, Russian</td>
<td><em>Salsola tragus</em></td>
</tr>
</tbody>
</table>
SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL (10/18)

<table>
<thead>
<tr>
<th>Mode of Action</th>
<th>BEN</th>
<th>BRO</th>
<th>CLE</th>
<th>DCP</th>
<th>DIM</th>
<th>ETH</th>
<th>FLM</th>
<th>FLU</th>
<th>GLY</th>
<th>MET*</th>
<th>OXY</th>
<th>PAR*</th>
<th>PEN</th>
<th>SET</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANNUAL WEEDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>barley, hare</td>
<td></td>
<td></td>
<td>P</td>
<td>N</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>barnyardgrass</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>bluegrass, annual</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>burclover, California</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>P</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>canarygrass</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>—</td>
<td>C</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>cereals</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td></td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>chickweed, common</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>crabgrass</td>
<td>C</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>cudweeds</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>dodders</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>—</td>
<td>N</td>
<td>—</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>fiddleeck</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>filarees</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>fleabane, hairy</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>foxtails</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>goosefoot</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>groundcherries</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>groundsel</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>henbit</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>horseweed</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>knotweed, common</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>kochia</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>lambsquarters, common</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>lettuce, prickly</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>lovegrasses</td>
<td>C</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>—</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>mallow, little (cheeseweed)</td>
<td>P</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>—</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>morningglories</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>mustards</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>nettle</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>nightshade, black</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>N</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>nightshade, hairy</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td>—</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>oat, wild</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>P</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>panicum, fall</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>—</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>pigweeds</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>puncturevine</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>purslane, common</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>radish, wild</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>rocket, London</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>ryegrasses</td>
<td>P</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>shepherd’s-purse</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>P</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>sowthistles</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>sunflowers</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>N</td>
<td>—</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>sweetclovers</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>P</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>swinecress, greater</td>
<td>N</td>
<td>N/P</td>
<td>N</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N/P</td>
<td>—</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>thistle, Russian</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td></td>
</tr>
</tbody>
</table>

PERENNIAL WEEDS

| bermudagrass (established) | N   | N   | P   | N   | —   | N   | N   | P   | C   | P   | N   | N   | N   | P   |
| bermudagrass (seedling)   | N   | N   | N   | N   | N   | N   | N   | N   | P   | P   | N   | N   | N   | N   |
| bindweed, field (established) | N  | N   | N   | N   | N   | N   | N   | N   | P   | P   | N   | N   | N   | N   |
| bindweed, field (seedling) | N   | P   | N   | N   | —   | N   | N   | N   | C   | P   | N   | P   | N   | N   |
| dock, curly (established) | N   | N   | N   | N   | N   | N   | N   | —   | C   | N   | N   | N   | N   | N   |
| dock, curly (seedling)    | P   | C   | N   | C   | —   | —   | N   | C   | C   | C   | C   | C   | N   | C   |
| johnsongrass (established) | N   | N   | C   | N   | —   | N   | N   | C   | C   | N   | N   | N   | C   | C   |
| johnsongrass (seedling)   | C   | N   | C   | C   | C   | C   | C   | C   | C   | C   | C   | C   | C   |     |
### Susceptibility of Weeds to Herbicide Control

**Mode of Action**

<table>
<thead>
<tr>
<th>Mode of Action</th>
<th>BEN</th>
<th>BRO</th>
<th>CLE</th>
<th>DCP</th>
<th>DIM</th>
<th>ETH</th>
<th>FLM</th>
<th>FLU</th>
<th>GLY</th>
<th>MET*</th>
<th>OXY</th>
<th>PAR*</th>
<th>PEN</th>
<th>SET</th>
</tr>
</thead>
<tbody>
<tr>
<td>nutsedge, purple</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>nutsedge, yellow</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>P</td>
<td>P</td>
<td>N</td>
<td>P</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>thistle, Canada</td>
<td>—</td>
<td>—</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>—</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>—</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

C = control      P = partial control      N = no control      — = no information

**BEN** = bensulide (Prefar)

**BRO** = bromoxynil (Brix)

**CLE** = clethodim (Select Max)

**DCP** = DCPA (Dacthal)

**DIM** = dimethenamid (Outlook)

**ETH** = ethofumesate (Ethofumesate)

**FLM** = flumioxazin (Chateau)

**FLU** = fluazifop-P-butyl (Fusilade)

**GLY** = glyphosate (Roundup)

**MET** = metam sodium or potassium* (Vapam, etc.)

**OXY** = oxyfluorfen (Goal, GoalTender)

**PAR** = paraquat* (Gramoxone)

**PEN** = pendimethalin (Prowl)

**SET** = sethoxydim (Poast)

*Permit required from county agricultural commissioner for purchase or use.

1 Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode-of-action numbers are useful in planning mixtures or rotations of herbicides with different modes of action.
### HERBICIDE TREATMENT TABLE (10/18)

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate</th>
<th>Application Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>XXX</strong></td>
<td>1 lb/acre</td>
<td><strong>FOOTNOTE</strong></td>
</tr>
</tbody>
</table>

*FOOTNOTE: Additional information and precautions.*
### Herbicide Treatment Table

**Herbicide** *(Example trade name)* | **Amount per acre** | **REI‡** *(hours)* | **PHI‡** *(days)*
--- | --- | --- | ---

Not all registered pesticides are listed. *The following are listed alphabetically.* When choosing a pesticide, consider information relating to environmental impact, resistance management, the pesticide’s properties, and application timing. Tank mixes may be necessary to achieve desired control; see the Susceptibility of Weeds to Herbicide Control for information on specific weed control. Always read the label of the product being used.

### PREPLANT

#### A. GLYPHOSATE *(Roundup PowerMAX)*

| WSSA MODE-OF-ACTION GROUP NUMBER| 9 |
| TIMING: | Can be used before planting or after planting, but before the crop emerges. |
| COMMENTS: | Registered for preplant use in onions (dry bulb and green), garlic, leek, and shallot. A nonselective, foliar herbicide applied before planting to pre-made beds to kill emerged weeds. Consult the label for specific recommendations on particular weed species. Do not apply to weeds stressed for moisture or weeds with significant dust. For perennial weeds, allow 7 days after application before cultivating. |

#### B. METAM POTASSIUM*§

| WSSA MODE-OF-ACTION GROUP NUMBER| 26 |
| TIMING: | Preplant only |
| COMMENTS: | Registered for use in onion, garlic, and leek. This fumigant is effective against nightshade and many other weeds. Beds must be free of large clods and the soil should be moistened by rainfall or irrigation before application. Applications are made using a spray blade cutting 2 to 3 inches below the soil surface, depending on soil moisture. Disc hillers follow directly behind the spray blade to form a 3- to 6-inch soil cap over the treated area. Other methods of application include shank and drench application. Fumigants such as metam potassium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone. |

#### C. METAM SODIUM*§

| WSSA MODE-OF-ACTION GROUP NUMBER| 26 |
| TIMING: | Preplant only |
| COMMENTS: | Registered for preplant use in onion, garlic, and leek. This fumigant is effective against nightshade and many other weeds. Beds must be free of large clods and the soil should be moistened by rainfall or irrigation before application. Applications are made using a spray blade cutting 2 to 3 inches below the soil surface, depending on soil moisture. Disc hillers follow directly behind the spray blade to form a 3- to 6-inch soil cap over the treated area. Other methods of application include shank and drench application. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone. |

#### D. PARAQUAT* *(Gramoxone SL 2.0)*

| WSSA MODE-OF-ACTION GROUP NUMBER| 22 |
| TIMING: | Either before planting or after planting, but before the crop emerges. |
| COMMENTS: | Registered for preplant use in garlic and direct-seeded onions. A nonselective foliar herbicide that kills emerged weeds. Any crop plants exposed to the spray will be killed, even germinating seed in the crook stage. No residual soil activity. Faster acting on warm, sunny days. |

### AT SEEDING OR TRANSPLANTING

#### A. DCPA *(Dacthal Flowable)*

| WSSA MODE-OF-ACTION GROUP NUMBER| 3 |
| TIMING: | Either at planting or after planting, before weeds emerge. |
| COMMENTS: | Registered for use in dry bulb onion, green onion, leek, and shallot. Not registered for use in garlic. DCPA can be sprayed directly over transplants without injury. Requires rainfall or irrigation for activation. Rate depends on soil type. Controls annual grasses and some annual broadleaf weeds. |
### POSTPLANT

**Before crop and weeds emerge, loop stage (when specified)**

<table>
<thead>
<tr>
<th>A.</th>
<th>BENSULIDE</th>
<th>5–6 lb a.i. 5–6 qt</th>
<th>12</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Prefar 4-E)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER:</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMING:</td>
<td>Either preplant or postplant, preemergence.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS:</td>
<td>Registered for use on bulb onions, garlic, and shallot, but recommended only for onions in California. Requires irrigation for activation. See label for optimal soil temperature and salinity conditions for preventing crop damage. Effective on annual grasses and on a broadleaf species such as knotweed, pigweed, and purslane.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B.</th>
<th>DCPA</th>
<th>4.5–10.5 lb a.i 6–14 pt</th>
<th>12</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Dacthal Flowable)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER:</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMING:</td>
<td>Either at planting or postplant, preemergence. Can be sprayed directly over transplants without injury.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS:</td>
<td>Registered for use in dry bulb onion, green onion, leek, and shallot. Not registered for use in garlic. Requires rainfall or irrigation for activation. Controls late-emerging annual grasses and some annual broadleaf weeds. Rate depends on soil type.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C.</th>
<th>ETHOFUMESATE</th>
<th>0.5–1 lb a.i. 16 fl oz (coarse soils) 32 fl oz (medium or fine soils)</th>
<th>12</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Ethofumesate 4SC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER:</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMING:</td>
<td>General preemergence application.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS:</td>
<td>Registered for use in garlic, dry bulb onions, and bulb shallot. Requires rainfall, sprinkler or furrow irrigation for activation.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D.</th>
<th>FLUMIOXAZIN</th>
<th>3.06 oz a.i 6 oz</th>
<th>12</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Chateau 5W)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER:</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMING:</td>
<td>Must be applied within 3 days after planting for preemergence use.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS:</td>
<td>Registered for use in garlic only. Weed control improves with rainfall or irrigation.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E.</th>
<th>GLYPHOSATE</th>
<th>Label rates</th>
<th>4</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Roundup PowerMAX)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER:</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMING:</td>
<td>Can be used before planting or after planting, but before the crop emerges.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS:</td>
<td>Registered for use in garlic, leek, onion (dry bulb and green), and shallot. A nonselective, foliar herbicide applied to beds to kill emerged weeds. Consult the label for specific recommendations on particular weed species. Do not apply to weeds stressed for moisture or weeds with significant dust. For perennial weeds, allow 7 days after application before cultivating.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F.</th>
<th>OXYFLUORFEN</th>
<th>Garlic: 1 pt Transplanted onion: 0.5–2 pt</th>
<th>48</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Goal 2XL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER:</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMING:</td>
<td>For transplanted onions, apply immediately after transplanting before weeds emerge. For direct-seeded garlic, apply after planting and before crop emergence. For all other crops, do not apply until after crop emerges (see CROP ESTABLISHED).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS:</td>
<td>Postplant, preemergence application registered for use in direct-seeded garlic and transplanted (NOT direct-seeded) dry bulb onions. In a ground application, apply in a spray volume of 40 to 60 gallons per acre for thorough weed coverage. This will also help avoid injury to the crop. Activated by rainfall or irrigation.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G.</th>
<th>PARAQUAT*</th>
<th>0.5 lb–1 lb a.i. Bulb onion: 2–4 pt Seeded onion and garlic: 2.5–4 pt</th>
<th>24</th>
<th>Onion: 60 Garlic: 200</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Gramoxone SL 2.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER:</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TIMING: Either before planting or after planting, but before the crop emerges. Any crop plants exposed to the spray will be killed, even germinating seed in the crock stage.

COMMENTS: Preemergence use registered for seeded onions, bulb onion, and garlic. No residual soil activity. Faster acting on warm, sunny days.

H. PENDIMETHALIN
   (Prowl H2O)  0.475–1.52 lb a.i.
   Onion: 1–3 pt (see Special Labels)
   Garlic: 1.5–3.2 pt
   Onions: 0.068–0.2425 lb a.i.
   0.5625–0.9843 lb a.i.
   12 fl oz
   12–21 fl oz
   16 fl oz
   12–21 fl oz
   24
   24
   45
   30

WSSA MODE-OF-ACTION GROUP NUMBER: 3
TIMING: For dry bulb onions, registered as a delayed preemergence herbicide (75% onion radical emergence) for kochia control in Lassen, Modoc, Shasta, and Siskiyou counties under a special label (EPA SLN No. CA-150008, Exp. Oct. 31, 2020). For dry bulb, direct-seeded onions, also registered statewide for application at the loop stage under a special label (EPA SLN No. CA-060029). For garlic, general postplant, preemergence application.

COMMENTS: Preemergence application registered for use in garlic and dry bulb onions (see onion specifications above). Application rates depend on soil type. Requires rainfall or irrigation for activation.

CROP ESTABLISHED

A. BROMOXYNIL
   (Brox 2EC) 0.25–0.375 lb a.i.
   Garlic: 2 pt
   Onion: 0
   Garlic: 112 (60 in muck soils)
   3 pt (see Special Labels)
   2 pt
   60

WSSA MODE-OF-ACTION GROUP NUMBER: 6
TIMING: For onion, chemigate or apply by ground when onions have 2 to 5 true leaves, and only apply it if the onion leaf cuticle has a waxy appearance. For garlic, may be applied any time after emergence before the crop is twelve inches tall. Weeds should not exceed the 4-leaf stage.

COMMENTS: Postemergence use registered for garlic and dry bulb onions only. Very good for control of shepherd’s purse, mustard species and Russian thistle. Very effective for control of small broadleaf weeds. If applied to plants with thin cuticles, bromoxynil can cause severe crop injury. Foliage needs to be dry at the time of application. Other conditions can lead to crop injury; consult label before application. Can be used in sequence with oxyfluorfen; use lower rates than those listed in tank mixes.

B. CLETHODIM
   (Select Max) 0.068–0.2425 lb a.i.
   Onion: 1–1.5 pt
   Garlic: 1.5–2 pt
   9–32 fl oz
   24
   45

WSSA MODE-OF-ACTION GROUP NUMBER: 1
TIMING: Apply only after crop has 2 or more true leaves.

COMMENTS: Labeled for use on dry bulb onion, garlic, and shallot. Controls annual bluegrass in the 2- to 3-leaf stage as well as other annual grasses and some perennial grasses. Do not apply through any type of irrigation system. Always apply with a crop oil concentrate. Rate differs for annual and perennial grasses.

C. DIMETHENAMID
   (Outlook) 0.5625–0.9843 lb a.i.
   Onion: 0
   Garlic: 30 (+/–)
   10/18
   12
   12
   30

WSSA MODE-OF-ACTION GROUP NUMBER: 15
TIMING: Apply only after the crop has more than 2 true leaves. If applying to fields infested with yellow nutsedge, apply before nutsedge emerges.

COMMENTS: Registered for use in garlic only. Provides control of yellow nutsedge and broadleaf weeds. Most effective when activated by sprinkler irrigation, rainfall, or mechanical incorporation. Amount per acre may be split into two applications rather than one (see label for specifics), but do not exceed a total maximum of 21 fl oz per acre in a single growing season. Maximum rate per season also depends on soil type and organic matter (see label). Use lower rates on coarse-textured soils and higher rates on medium- and fine-textured soils.

D. ETHOFUMESATE
   (Ethofumesate 4SC) 0.5 a.i.
   16 fl oz
   12
   30 (+/–2)

WSSA MODE-OF-ACTION GROUP NUMBER: 8
TIMING: General postemergence application.

COMMENTS: Registered for use in garlic, dry bulb onion, and bulb shallot only. Requires rainfall, sprinkler irrigation or furrow irrigation for activation. Controls a variety of broadleaf and grass weeds.
A. DCPA (Dacthal Flowable) 4.5–10.5 lb a.i. 4.5–10.5 lb a.i. 6–14 pt NA 12 NA

B. FLUAZIFOP-P-BUTYL (Fusilade DX) 0.12–0.25 lb a.i. 0.12–0.25 lb a.i. 12 48

C. OXYFLUORFEN (Goal 2X) 0.71–1.52 lb a.i. 0.71–1.52 lb a.i. 12 48

D. PENDIMETHALIN (Prowl 3.3 EC) 1.8–3.6 pt 24 60

E. OXYFLUORFEN (GoalTender) 0.12–0.25 lb a.i. 0.12–0.25 lb a.i. 12 48

F. OXYFLUORFEN (Goal 2X) 0.71–1.52 lb a.i. 0.71–1.52 lb a.i. 12 48

G. PENDIMETHALIN (Prowl 3.3 EC) 1.8–3.6 pt 24 60

H. SETHOXYDIM (Poast) 1.0–1.5 pt 12 30

LAYBY
TIMING: After weeds are cultivated or handweeded during the layby period. Does not control emerged weeds.

COMMENTS: Registered for use in onions (bulb and green), leeks, and shallots. Not registered for use in garlic. Good control of annual grasses and some annual broadleaf weeds.

B. PENDIMETHALIN (Prowl H2O)
   Coarse soil texture: 1.5 pt  24  60
   Medium texture: 2.0 pt
   Fine soil texture: 3.2 pt

WSSA MODE-OF-ACTION GROUP NUMBER*: 3

TIMING: May be applied to onion and shallot between the 2- and 6- leaf stages, and garlic between the 1st and 5- leaf stages.

COMMENTS: Registered for use in garlic, bulb onion, and bulb shallot. Controls many broadleaf weeds and annual grasses.

PREHARVEST

A. GLYPHOSATE (Roundup PowerMAX) 22–44 fl oz  4  30

WSSA MODE-OF-ACTION GROUP NUMBER*: 9

TIMING: After the last irrigation and before removing the top of the crop.

COMMENTS: Registered for preharvest use only in onions and garlic grown for processing (dehydration), for suppression of nutsedge and field bindweed, under a Special Local Needs label (SLN No. CA-170011, expires August 31, 2022). Apply by ground sprayer equipment only. In addition to nutsedge and bindweed, also effective at drying down nightshade. Avoid contact with the crop; otherwise severe damage may occur.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

1 Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode-of-action numbers are useful in planning mixtures or rotations of herbicides with different modes of action.
PRECAUTIONS FOR USING PESTICIDES

Pesticides are poisonous and must be used with caution. READ THE LABEL BEFORE OPENING A PESTICIDE CONTAINER. Follow all label precautions and directions, including requirements for protective equipment. Apply pesticides only on the crops or in the situations listed on the label. Apply pesticides at the rates specified on the label or at lower rates if suggested in this publication. In California, all agricultural uses of pesticides must be reported. Contact your county agricultural commissioner for further details. Laws, regulations, and information concerning pesticides change frequently. This publication reflects legal restrictions current on the date next to each pest’s name.

Legal Responsibility
The user is legally responsible for any damage due to misuse of pesticides. Responsibility extends to effects caused by drift, runoff, or residues.

Transportation
Do not ship or carry pesticides together with food or feed in a way that allows contamination of the edible items. Never transport pesticides in a closed passenger vehicle or in a closed cab.

Storage. Keep pesticides in original containers until used. Store them in a locked cabinet, building, or fenced area where they are not accessible to children, unauthorized persons, pets, or livestock. DO NOT store pesticides with foods, feed, fertilizers, or other materials that may become contaminated by the pesticides.

Container Disposal
Dispose of empty containers carefully. Never reuse them. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Consult your county agricultural commissioner for correct procedures for handling and disposal of large quantities of empty containers.

Protection of Nonpest Animals and Plants
Many pesticides are toxic to useful or desirable animals, including honey bees, natural enemies, fish, domestic animals, and birds. Crops and other plants may also be damaged by misapplied pesticides. Take precautions to protect nonpest species from direct exposure to pesticides and from contamination due to drift, runoff, or residues. Certain rodenticides may pose a special hazard to animals that eat poisoned rodents.

Posting Treated Fields
For some materials, restricted entry intervals are established to protect field workers. Keep workers out of the field for the required time after application and, when required by regulations, post the treated areas with signs indicating the safe re-entry date. Check with your county agricultural commissioner for latest restricted entry intervals.

Preharvest Intervals
Some materials or rates cannot be used in certain crops within a specified time before harvest. Follow pesticide label instructions and allow the required time between application and harvest.

Permit Requirements
Many pesticides require a permit from the county agricultural commissioner before possession or use. When such materials are recommended, they are marked with an asterisk (*) in the treatment tables or chemical sections of this publication.

Maximum residue levels
Before applying pesticides to crops destined for export, check maximum residue levels (MRLs) of the importing country.

Processed Crops
Some processors will not accept a crop treated with certain chemicals. If your crop is going to a processor, be sure to check with the processor before applying a pesticide.

Crop Injury
Certain chemicals may cause injury to crops (phytotoxicity) under certain conditions. Always consult the label for limitations. Before applying any pesticide, take into account the stage of plant development, the soil type and condition, the temperature, moisture, and wind. Injury may also result from the use of incompatible materials.

Personal Safety
Follow label directions carefully. Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. NEVER eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care IN ADVANCE as required by regulation.
UC ANR policy also prohibits retaliation against any employee or person in any of its programs or activities for bringing a complaint of discrimination or sexual harassment. UC ANR policy also prohibits retaliation against a person who assists someone with a complaint of discrimination or harassment, or participates in any manner in an investigation or resolution of a complaint of discrimination or harassment. Retaliation includes threats, intimidation, reprisals, and/or adverse actions related to any of its programs or activities.

UC ANR is an Equal Opportunity/Affirmative Action Employer. All qualified applicants will receive consideration for employment and/or participation in any of its programs or activities without regard to race, color, religion, sex, national origin, disability, age or protected veteran status.

University policy is intended to be consistent with the provisions of applicable State and Federal laws.

Inquiries regarding the University’s nondiscrimination policies may be directed to: UCANR, Affirmative Action Compliance and Title IX Officer, University of California, Agriculture and Natural Resources, 2801 Second Street, Davis, CA. 95618, (530) 750-1397. Email: jsafox@ucanr.edu.

Website: http://ucanr.edu/sites/anrstaff/Diversity/Affirmative_Action/.