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An illustrated version of this guideline is available online at http://www.ipm.ucanr.edu/PMG/selectnewpest.cole-crops.html
http://www.ipm.ucanr.edu/PMG/selectnewpest.cole-crops.html

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University of California
Agriculture and Natural Resources
Statewide Integrated Pest Management Program
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Authors

Insects, Mites, and Other Invertebrates: E. T. Natwick (emeritus), UC Cooperative Extension Imperial County; S. V. Joseph, Entomology, University of Georgia; S. K. Dara, UC Cooperative Extension San Luis Obispo and Santa Barbara counties

Diseases: S. T. Koike, TriCal Diagnostics, Hollister; K. V. Subbarao, Plant Pathology, UC Davis

Nematodes: B. B. Westerdahl, Nematology, UC Davis; A. Ploeg, Nematology, UC Riverside

Weeds: O. Daugovish, UC Cooperative Extension Ventura County; R. F. Smith, UC Cooperative Extension Monterey County; S. A. Fennimore, UC Cooperative Extension Monterey County.

Vertebrates: R. A. Baldwin, Wildlife, Fish and Conservation Biology, UC Davis.

Crop Leadership Team: T. A. Turini, UC Cooperative Extension Fresno County (crop team leader); S. K. Dara, UC Cooperative Extension San Luis Obispo and Santa Barbara counties (IPM facilitator); S. P. Parreira, UC IPM Program (coordinator); R. A. Baldwin, Wildlife, Fish and Conservation Biology, UC Davis; O. Daugovish, UC Cooperative Extension Ventura County; A. Ploeg, Nematology, UC Riverside.

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Insects, Mites, and Other Invertebrates: W. J. Bentley, UC IPM, Kearney Agricultural Research and Extension Center, Parlier; W. E. Chaney, UC Cooperative Extension Monterey County; N. C. Toscano, Entomology, UC Riverside

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

Weeds: W. T. Lanini (emeritus), Plant Sciences, UC Davis; M. Le Strange (emeritus), UC Cooperative Extension, Tulare County

Year-Round IPM Program Development: E. T. Natwick (emeritus), UC Cooperative Extension Imperial County; K. A. Osienski, UC IPM; S. T. Koike, TriCal Diagnostics, Hollister.

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

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• Online: http://www.ipm.ucanr.edu
• UC Cooperative Extension: County Offices
• University of California
  ANR Communication Services
  2801 Second Street
  Davis, CA 95616-7779
  530-750-1213; 800-994-8849
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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 the latest restricted entry intervals.

To be used with UC ANR Publication 3307, Integrated Pest Management for Cole Crops and Lettuce
Use these guidelines for a monitoring-based IPM program to effectively manage pests, while reducing the risks of pesticides on the environment and human health.

When a pesticide application is considered, review the Pesticide Application Checklist for information on how to minimize the risks of pesticide use to water and air quality. Water quality can be impaired when pesticides drift to waterways or when they move off-site. Air quality can be impaired when pesticide applications release volatile organic compounds (VOCs) into the atmosphere.

This year-round IPM program covers the major pests of cole crops in the Central Valley, Central and Southern Coast, and southern desert of California. Details on carrying out each practice, example monitoring forms, and information on additional pests can be found in the *Pest Management Guidelines: Cole Crops*. Color photo identification pages and example monitoring forms can be found at the forms and photo identification pages.

<table>
<thead>
<tr>
<th>✓ Done</th>
<th>Preplant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Special issues of concern related to environmental quality: pesticide and fertilizer runoff and leaching. Mitigate pesticide effects on air and water quality.</td>
</tr>
<tr>
<td></td>
<td>If nematodes have not been previously identified, take soil samples preferably while the previous crop is still in the field.</td>
</tr>
</tbody>
</table>

Select the field:
- Consider the soil type, plantback restrictions from previously applied pesticides, and rotational plan for the field.
- Consider crop, pest, and pest management history, especially:
  - Clubroot: if lime was not applied in the previous crop, apply lime this season or choose another field if the field has a history of clubroot.
  - Damping-off (wirestem): if the field has a history of severe damping-off, do not transplant cauliflower.
  - Nutsedge and field bindweed: if the abundance of either is moderate to high, consider planting to a different field.
  - Cyst nematodes: if present in soil samples and damage was noted in the previous crop, consider applying a nematicide or plant to another field.
  - Root-knot nematodes: if detected in soil samples, if the field has sandy soil, and these nematodes have caused problems previously in sugarbeet or other crops, consider applying a nematicide or plant to another field.
  - Fumigation of the previous crop may greatly reduce soilborne pathogens and nematodes and benefit the current crop.
- Take a soil sample for analysis of nutrients, pH, and salinity to determine field suitability and soil nutrient management.

Manage weeds according to the Pest Management Guidelines:
- Survey weeds and keep records, noting the presence of weed problems including herbicide-resistant weeds and volunteer crucifers.
- Based on weed infestations in previous crops, decide if a preemergence herbicide is needed.
- While surveying weeds around field edges, monitor for Bagrada bug (especially on cruciferous weeds), crickets and sowbugs (if the crop is direct-seeded), cutworms (if crop is direct-seeded), lygus bugs, and darkling beetles. Remove any weeds before they flower.
- Control weeds now to help prevent damage from aphids (cabbage aphid and other aphids), beet armyworm, cutworms, and flea beetles. Weeds can also harbor plant pathogens such as those that cause black leg, black rot, and ring spot.
- Create a custom herbicide weed susceptibility chart for your field.

Monitor for soil-dwelling pests such as garden symphylans and springtails:
- Place at least a dozen covered baits (such as potato or beet slices) throughout the field.
- Check the baits for symphylans (and springtails in the Salinas Valley) 24 to 36 hours later.
Manage if needed according to the Pest Management Guidelines.

Clean equipment and tractors before they enter the field to prevent the spread of soilborne pathogens, weed seeds, and perennial propagules. Screen surface water sources of irrigation to avoid spreading weed seeds.

Prepare the field:
- Manage residue from weeds and the previous crop by properly cultivating the field to prevent the spread of garden symphylans, springtails, bulb mites, pathogens, and root- and crown-feeding insects, unless practicing reduced tillage or no-till agriculture.
- Prepare seed beds and provide good drainage.

Make phosphorus, potassium, and nitrogen fertilizer decisions based on soil tests. Make nitrogen fertilizer applications based on quantities of residual soil nitrate in the soil.
See the following publications for more information about fertilization requirements:
- Using the Pre-Sidedressing Soil Nitrate ‘Quick Test’ to Guide N Fertilizer Requirements (PDF)
- Broccoli Production in California, UC ANR Publication 7211 (PDF)
- Cabbage Production in California, UC ANR Publication 7208 (PDF)
- Cauliflower Production in California, UC ANR Publication 7219 (PDF)
- The online decision support tool CropManage can also help guide nitrogen fertilizer decisions.

Manage disease.
- Choose less-susceptible cultivars.
- Use transplants and seeds that have been tested for pathogens and found to be pathogen-free, if possible. If seedborne pathogens such as Alternaria leaf spot, bacterial leaf spot, black rot, and black leg are detected, manage as necessary according to the Pest Management Guidelines.

✓ Done

Planting to Rosette

Special issues of concern related to environmental quality: pesticide and fertilizer runoff and leaching. Mitigate pesticide effects on air and water quality

Monitor for Bagrada bug and its eggs in nurseries. Do not use transplants with damage from pests or diseases.

In the Central Coast region, monitor weeds around the field for lygus bugs. Manage as needed according to the Pest Management Guidelines.

At planting, select and apply herbicides if needed based on the preplant weed survey.

Direct seed or transplant into uniform beds to the proper depth with a precision planting system.
Check for stand uniformity and wilted plants. Inspect plants for pests and their damage:

- Aphids (cabbage aphid and other aphids)
- Bagrada bug
- Beet armyworm (eggs and newly hatched larvae)
- Bulb mites (only for direct-seeded crops)
- Cabbage looper (eggs and newly hatched larvae)
- Cabbage maggot
- Crickets (if the crop is direct-seeded)
- Cutworms
- Darkling beetles
- Diamondback moth (in coastal areas)
- Flea beetles
- Garden symphylan
- Grasshoppers (if crop is direct-seeded)
- Leafminers
- Leaffoppers
- Lygus bugs (in the Central Coast region)
- Seedcorn maggot
- Sowbugs (if the crop is direct-seeded)
- Springtails (for direct-seeded crops in the Salinas Valley)
- Sweetpotato whitefly
- Wireworms

Manage as needed according to the Pest Management Guidelines.

Before cultivation, manage emerged weeds according to the Pest Management Guidelines.

- Survey the field to identify the weeds growing. Continue to keep records.
- Cultivate as close to the seed line as possible. Based on the weeds present, decide if a postemergence herbicide is needed and use a surface band application of salt-based fertilizer to stimulate growth and kill weeds. Grass-selective herbicides can also be used if these weeds are present.
- If herbicides are used, create a custom herbicide weed susceptibility chart for your field.

If you observe severe symptoms of clubroot or Rhizoctonia diseases, note the location for future spot treatments if cole crops will be planted again, or to make management decisions for the next crop.

If you see these sporadic or minor pests, diseases, or disorders, note for next year's management:

- Alternaria leaf spot
- Cabbage looper
- Downy mildew
- Imported cabbageworm
- Vertebrates (birds, mice, or voles)
- Wind damage, or wind whip girdling of stems

Manage the pests listed above as needed according to the Pest Management Guidelines. For more information on abiotic disorders, see Integrated Pest Management for Cole Crops and Lettuce, UC ANR Publication 3307 (available as a PDF only). Keep records for next year's management.

Install drip tape if sprinklers were used to establish the crop.

**Done**

**Rosette to Heading**

**Special issues of concern related to environmental quality:** pesticide and fertilizer runoff and leaching. Mitigate pesticide effects on air and water quality.

If you observe symptoms of Fusarium yellows or Verticillium wilt, note for future management.
Make nitrogen, phosphorus and potassium fertilizer decisions based on soil tests (however, these are generally applied preplant). Make nitrogen fertilizer applications based on quantities of residual soil nitrate.

- The online decision support tool CropManage can help guide nitrogen fertilizer decisions.
- See the following publications for more information:
  - Using the Pre-Sidedressing Soil Nitrate ‘Quick Test’ to Guide N Fertilizer Requirements (PDF)
  - Broccoli Production in California, UC ANR Publication 7211 (PDF).
  - Cabbage Production in California, UC ANR Publication 7208 (PDF).
  - Cauliflower Production in California, UC ANR Publication 7219 (PDF).

Decide if hand weeding is needed to remove weeds before the canopy closes.

Monitor for pests and their damage and manage as needed according to the Pest Management Guidelines:

- Aphids (cabbage aphid and other aphids)
- Bagrada bug
- Beet armyworm
- Cabbage looper
- Diamondback moth
- Garden symphylan
- Imported cabbageworm, except in southern desert where it is rarely a problem.
- Cabbage webworm (in the southern desert, where it is an occasional problem)
- Leafrollers
- Thrips

✓ Done

Heading to Harvest

Special issues of concern related to environmental quality: pesticide and fertilizer runoff and leaching. Mitigate pesticide effects on air and water quality.

Monitor the presence and abundance of weeds. Keep records for next season’s management.

Monitor for pests and their damage:

- Aphids (cabbage aphid and other aphids)
- Beet armyworm
- Cabbage looper
- Imported cabbageworm (except in southern desert)
- Leafrollers
- Sweetpotato whitefly
- Thrips

Manage according to the Pest Management Guidelines.

Monitor for and identify crop quality issues and note these for next year’s management.

- Bacterial head rot in broccoli
- Downy mildew in broccoli and cauliflower
- White stem in broccoli
- Abiotic disorders:
  - Broccoli brown bead
  - Calcium deficiency in cauliflower
  - Cracked stem
  - Hollow stem in broccoli
If necessary, make nitrogen, phosphorus and potassium fertilizer decisions on soil tests; however, these are generally not needed late in the crop cycle. Base nitrogen fertilizer applications on quantities of residual soil nitrate in the soil.

- CropManage can help guide nitrogen fertilizer decisions.
- See the following publications for more information:
  - Using the Pre-Sidedressing Soil Nitrate ‘Quick Test’ to Guide N Fertilizer Requirements (PDF)
  - Broccoli Production in California, UC ANR Publication 7211 (PDF)
  - Cabbage Production in California, UC ANR Publication 7208 (PDF)
  - Cauliflower Production in California, UC ANR Publication 7219 (PDF).

Clean harvest equipment and tractors before they enter the field to prevent the spread of soilborne pathogens, weed seeds, and perennial propagules. Screen surface water sources of irrigation to avoid spreading weed seeds.

Note the presence and abundance of disease from soilborne pathogens at harvest for planning next season’s management.

- Clubroot
- Fusarium yellows
- Rhizoctonia diseases
- Verticillium wilt

Examine roots of stunted plants for the brown, egg-filled bodies of cyst nematodes and galling on the roots from root-knot nematodes.

**Done**

**Harvest and Postharvest**

Mitigate pesticide effects on air and water quality.

Immediately after harvest, shred and disc under crop remnants if the following pests were a problem:

- Aphids (cabbage aphid and other aphids)
- Bagrada bug
- Beet armyworm
- Bulb mites
- Cabbage looper
- Cabbage maggot
- Cutworms
- Diamondback moth
- Garden symphylan
- Imported cabbageworm
- Leafrollers
- Springtails
- Sweetpotato whitefly
- Wireworms

Remove drip tape and prepare the soil for the next crop or winter fallow.

Plan next season’s crop rotation.

- In coastal regions, avoid planting consecutive seasons of cole crops or other crops in the mustard family (Brassicaceae).
  - If Bagrada bug was a problem during the previous season, rotate to a nonhost such as lettuce or spinach.
- In the low desert, successive plantings of cole crops in the fall and spring are acceptable, because the hot, dry summers are unfavorable to many pests.
- If cover crops fit into the crop rotation, consider planting fast-growing cover crops that are competitive with weeds if there will be a fallow period.
  - In coastal regions, avoid rotating to a cruciferous cover crop such as Indian mustard or white mustard if Bagrada bug was a problem this season.
  - For more information, see Cover Cropping for Vegetable Production, UC ANR Publication 3517 (PDF).
### Pesticide application checklist

When planning for possible pesticide applications in an IPM program, consult the Pest Management Guidelines, and review and complete this checklist to consider practices that minimize environmental and efficacy problems.

<table>
<thead>
<tr>
<th>Choose a pesticide from the Pest Management Guidelines for the target pest, considering:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact on natural enemies and pollinators. For more information see Protecting Natural Enemies and Pollinators at <a href="http://ipm.ucanr.edu/mitigation/protect_beneficials.html">http://ipm.ucanr.edu/mitigation/protect_beneficials.html</a>.</td>
</tr>
<tr>
<td>Potential for water quality problems using the UC IPM WaterTox database. See <a href="http://ipm.ucanr.edu/TOX/simplewatertox.html">http://ipm.ucanr.edu/TOX/simplewatertox.html</a>.</td>
</tr>
<tr>
<td>Impact on aquatic invertebrates. For more information, see Pesticide Choice, UC ANR Publication 8161 (PDF), <a href="http://anrcatalog.ucanr.edu/pdf/8161.pdf">http://anrcatalog.ucanr.edu/pdf/8161.pdf</a>.</td>
</tr>
<tr>
<td>Chemical mode of action, if pesticide resistance is an issue. For more information, see:</td>
</tr>
<tr>
<td>- Herbicide Resistance: Definition and Management Strategies, UC ANR Publication 8012 (PDF).</td>
</tr>
<tr>
<td>- Fungicide Resistance in Crop Pathogens: How Can It Be Managed?</td>
</tr>
<tr>
<td>Endangered species that may be near your site. Find out using the Department of Pesticide Regulation's PRESCRIBE program. (<a href="https://cdpr.ca.gov/docs/endspec/prescint.htm">https://cdpr.ca.gov/docs/endspec/prescint.htm</a>)</td>
</tr>
</tbody>
</table>

### Before an application:

- Ensure that spray equipment is properly calibrated to deliver the desired pesticide amount for optimal coverage. See [http://ipm.ucanr.edu/training/incorporating-calibration.html](http://ipm.ucanr.edu/training/incorporating-calibration.html).
- Use appropriate spray nozzles and pressure to minimize off-site movement of pesticides.
- Choose sprayers and application procedures that keep pesticides on target.
- Avoid spraying during these conditions to avoid off-site movement of pesticides.
  - Wind speed under 3 mph or over 10 mph
  - Temperature inversions
  - Just prior to rain or irrigation (unless it is an appropriate amount, such as when incorporating a soil-applied pesticide)
  - At tractor speeds over 2 mph
- Identify and take special care to protect sensitive areas (for example, waterways or riparian areas) surrounding your application site.
- Review and follow labeling for pesticide handling, personal protection equipment (PPE) requirements, storage, and disposal guidelines.
- Check and follow restricted entry intervals (REI) and preharvest intervals (PHI).

### After an application:

- Record application date, product used, rate, and location of application.
- Follow up to confirm that the pesticide application was effective.

### Considering water management practices that reduce pesticide movement off-site:

- Consult relevant publications:
- Install sediment traps.
- Consult the Department of Pesticide Regulation Groundwater Protection Program (GWPA) website for pesticide information and mitigation measures. ([http://cdpr.ca.gov](http://cdpr.ca.gov))
- Install an irrigation recirculation or storage and reuse system. Redesign inlets to reduce erosion. For more information, see these publications:
### Cole Crops Year-Round IPM Program Checklist


<table>
<thead>
<tr>
<th>Practices to Consider</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use drip rather than sprinkler or flood irrigation.</td>
<td></td>
</tr>
<tr>
<td>Limit irrigation to the amount required using soil moisture monitoring and evapotranspiration (ET). Use CropManage to guide irrigations.</td>
<td></td>
</tr>
<tr>
<td>Consider using cover crops.</td>
<td></td>
</tr>
<tr>
<td>Consider vegetative filter strips or ditches. (For more information, see Vegetative Filter Strips, UC ANR Publication 8195 (PDF), <a href="https://anrcatalog.ucanr.edu/pdf/8195.pdf">https://anrcatalog.ucanr.edu/pdf/8195.pdf</a>.)</td>
<td></td>
</tr>
<tr>
<td>Apply polyacrylamide (PAM) tablets in furrow and sprinkler irrigation systems to prevent off-site movement of sediments.</td>
<td></td>
</tr>
<tr>
<td><strong>Consider practices that reduce air quality problems.</strong></td>
<td></td>
</tr>
<tr>
<td>When possible, reduce volatile organic compound (VOC) emissions by decreasing the amount of pesticide applied, choosing low-emission management methods, and avoiding fumigants and emulsifiable concentrate (EC) formulations.</td>
<td></td>
</tr>
</tbody>
</table>

For more information about mitigating the effects of pesticides, see *Mitigating Pesticide Hazards*. 

---
## Insects, Mites, and Other Invertebrates

### RELATIVE TOXICITIES OF INSECTICIDES AND MITICIDES USED IN COLE CROPS TO NATURAL ENEMIES AND HONEY BEES (12/20)

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Mode of action</th>
<th>Selectivity</th>
<th>Predatory mites</th>
<th>General predators</th>
<th>Parasites</th>
<th>Honey bees</th>
<th>Duration of impact to natural enemies</th>
</tr>
</thead>
<tbody>
<tr>
<td>acephate (Orthene)</td>
<td>1B</td>
<td>broad</td>
<td>H</td>
<td>H</td>
<td>M/H</td>
<td>I</td>
<td>moderate</td>
</tr>
<tr>
<td>acetamiprid (Assail)</td>
<td>4A</td>
<td>moderate</td>
<td>--</td>
<td>--</td>
<td>7</td>
<td>8</td>
<td>II moderate</td>
</tr>
<tr>
<td>azadirachtin (DeBug, Aza-Direct)</td>
<td>un</td>
<td>broad</td>
<td>M</td>
<td>L/M</td>
<td>L/M</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td><em>Bacillus thuringiensis</em> ssp. aizawai (Agree)</td>
<td>11A</td>
<td>narrow</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td><em>Bacillus thuringiensis</em> ssp. kurstaki (Condor)</td>
<td>11A</td>
<td>narrow</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>III</td>
<td>short</td>
</tr>
<tr>
<td>Beauveria bassiana strain GHA (Mycotrol)</td>
<td>--</td>
<td>broad</td>
<td>L</td>
<td>L/M</td>
<td>L</td>
<td>II</td>
<td>--</td>
</tr>
<tr>
<td>beta-cyfluthrin (Baythroid)</td>
<td>3A</td>
<td>broad</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate to long</td>
</tr>
<tr>
<td>bifenthrin (Brigade, Capture)</td>
<td>3A</td>
<td>broad</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>long</td>
</tr>
<tr>
<td>buprofezin (Courier)</td>
<td>16</td>
<td>narrow</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>II</td>
<td>long</td>
</tr>
<tr>
<td>heat-killed <em>Burkholderia</em> spp. strain A396 and spent fermentation media (Venerate)</td>
<td>--</td>
<td>broad</td>
<td>L</td>
<td>--</td>
<td>--</td>
<td>II</td>
<td>--</td>
</tr>
<tr>
<td>carbaryl bait (Sevin bait)</td>
<td>1A</td>
<td>narrow</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>III</td>
<td>short</td>
</tr>
<tr>
<td>carbaryl (Sevin)</td>
<td>1A</td>
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<td>M/H</td>
<td>H</td>
<td>H</td>
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<tr>
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<td>L</td>
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<td>L/M</td>
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<td>--</td>
<td>M/H</td>
<td>M/H</td>
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<td>long</td>
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<td>--</td>
<td>--</td>
<td>L</td>
<td>I</td>
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<td>cryolite (Prokil)</td>
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<td>L</td>
<td>III</td>
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<tr>
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<td>28</td>
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<td>--</td>
<td>L</td>
<td>L</td>
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<td>cyromazine (Trigard)</td>
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<td>L</td>
<td>L</td>
<td>L</td>
<td>II</td>
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<td>L</td>
<td>H</td>
<td>H</td>
<td>I</td>
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Illustrated version at ipm.ucanr.edu/agriculture/cole-crops/
<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Relative Toxicity</th>
<th>Formulation</th>
<th>Description</th>
<th>Toxicity</th>
<th>Behavior</th>
<th>Notes</th>
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<tr>
<td>dinotefuran (Scorpion, Venom)</td>
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<td>narrow (sucking insects)</td>
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<td>emamectin benzoate (Proclaim)</td>
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<td>esfenvalerate (Asana)</td>
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<td>broad (insects)</td>
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<td>L L L II short</td>
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<td>novaluron (Rimon)</td>
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<tr>
<td>permethrin (Perm-Up)</td>
<td>3A</td>
<td>broad (insects, sucking insects)</td>
<td>L H H I long</td>
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<tr>
<td>polyhedral occlusion bodies (OBs) of the nucleopolyhedrovirus of Spodoptera exigua (Spod-X)</td>
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<td>— M M I short</td>
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<tr>
<td>spinetoram (Radiant)</td>
<td>5</td>
<td>narrow (aphids, caterpillars, leafminers, whiteflies)</td>
<td>L/H M^9 L/M II moderate^9</td>
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<tr>
<td>spinosad bait (Seduce)</td>
<td></td>
<td>narrow (cutworms)</td>
<td>L L L II none to short</td>
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<tr>
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<td>spinosad (Oberon)</td>
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<tr>
<td>spiratom (Oberon)</td>
<td>23</td>
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<td>— — — II —</td>
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<tr>
<td>sulfoxaflor (Sequoia)</td>
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<td>Insecticide</td>
<td>Mode of Action</td>
<td>Selectivity</td>
<td>Toxicity</td>
<td>Duration</td>
<td>Comments</td>
<td></td>
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<tr>
<td>-------------------------------------</td>
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</tr>
<tr>
<td>thiamethoxam (Actara, Platinum)</td>
<td>4A</td>
<td>narrow (sucking insects)</td>
<td>—/ —</td>
<td>M</td>
<td>I</td>
<td>moderate</td>
</tr>
<tr>
<td>thiamethoxam/chlorantraniliprole</td>
<td>4A/28</td>
<td>broad (caterpillars, maggots, sucking insects)</td>
<td>—/ —</td>
<td>—</td>
<td>—</td>
<td>I/III moderate</td>
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<tr>
<td>zeta-cypermethrin (Mustang)</td>
<td>3A</td>
<td>broad (insects, mites)</td>
<td>H</td>
<td>M</td>
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<td>I</td>
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</tbody>
</table>

**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 Guidelines database, and from Flint, M. L. and S. H. Dreistadt. 1998. *Natural Enemies Handbook: An Illustrated Guide to Biological Pest Control*, UC ANR Publication 3386.
**BAGRADA BUG** (12/20)

**Scientific Name:** *Bagrada hilaris*

**DESCRIPTION OF THE PEST**

Bagrada bug adults are 0.2 to 0.3 inch (5–7 mm) long, shield-shaped stink bugs. Adults are black with orange-and-white markings. They resemble harlequin bugs, but are smaller at about one-third to one-fifth the size. The wingless Bagrada bug nymphs develop through five instars. Newly molted nymphs of all ages are orange-red, but the legs, head, and thorax darken to black as nymphs get older. Male bugs are slightly smaller than females. Females lay cream-colored, barrel-shaped eggs in or on the soil surface, as well as on leaves and stems. Eggs turn orange-red as embryos mature inside.

Bagrada bugs feed on a wide variety of different crops, including cotton, legumes, strawberries, melons, potatoes, peppers, tomatoes, and grains (wheat, corn, sudangrass, and millet). They typically move into cole crops from surrounding weeds in late spring to summer, and up to fall in some regions. Specific timing of these infestations can vary between years and between regions.

**DAMAGE**

Bagrada bugs insert their needlelike mouthparts into plant tissues and suck the sap. They can kill germinating seeds, seedlings, or young transplants when they feed on the apical meristem (terminal bud). White, starburst-shaped lesions and stippled areas develop on leaves and stems, which may wilt and die. Such damage on leafy cole crops such as mizuna and other non-cole crop *Brassica* greens such as arugula can render the crop unmarketable. When bug feeding damage causes meristematic tissues to die, heads do not form (also known as blind terminals). Other damage from Bagrada bug feeding may include forked buds, multiple heads, or leaves with brown or white dead blotches. It can also cause stunting on broccoli, cabbage, and cauliflower and render them unmarketable.

With high numbers of Bagrada bugs, young plants and germinating seeds that are left unprotected can be significantly damaged within a day. Even with multiple insecticide applications on a 3- to 5- day schedule, migrating adult bugs can cause up to 20 or 30% damage to emerging seedlings and young transplants, depending on the severity of the infestation. Damage can be severe in both organic and conventional crops.

Because adults and nymphs move from weeds into direct-seeded and transplanted cole crops, damage from the Bagrada bug may be initially visible in the perimeter of the field. However, the infestation can rapidly progress throughout the field, as the adults are highly mobile. Fields that are near grassy areas, weedy areas (especially with cruciferous weeds), lush desert habitat, and residential areas with preferred hosts have a higher risk of being damaged by Bagrada bug.

**MANAGEMENT**

Rely on monitoring, cultural controls, and insecticide applications to manage Bagrada bug. Frequently monitor susceptible crops and vegetation (including weeds) around fields or weak or stressed plants in the field. Monitor for Bagrada bug in the midday hours if possible, as these bugs tend to hide in cracks or crevices, or on the undersides of leaves, when temperatures are cooler. If using cross-vane traps, use black traps, as these attract the most adult bugs.
Biological Control
No natural enemies are known to effectively reduce Bagrada bug numbers in California or Arizona. Rove beetles and predatory ants may feed on Bagrada bug eggs in the soil, but these insects are not likely to keep Bagrada bug below damaging numbers.

Cultural Control
Depending on your region, consider using crop rotation to manage Bagrada bug. In coastal areas, rotate to a non-Brassica crop, preferably a nonhost such as lettuce or spinach. In the southern desert, crop rotation for Bagrada bug is not usually necessary.

If using crop rotation, keep in mind that Bagrada bug can survive on many other crops, especially solanaceous crops like tomato, pepper and potato, though they do not reach the same numbers in those crops as they do in cole crops and other Brassica crops. Management with crop rotation may differ between regions. For example, rotating to pepper or tomato after a Bagrada bug infestation in cole crops does not pose a problem in the southern desert but may encourage Bagrada bug survival in other regions.

The following cultural controls can also be used to prevent yield loss from Bagrada bug:
- Remove weed hosts, especially perennial pepperweed, shortpod mustard, wild radish, and volunteer weeds in the Brassicaceae family.
- Cultivate to destroy bugs and their eggs in the soil.
- If using transplants from an infested area, ask the producer about their Bagrada bug control program.
- Examine transplants in the trays and ensure they are free of Bagrada bugs and damage before planting.
- Monitor transplants regularly after planting.

Exclusion or row covers may prevent damage, but research on their effectiveness has not been done. Make sure the row covers are deployed immediately after direct seeding or transplanting, especially for cauliflower and broccoli. Overhead irrigation does not reduce Bagrada bug numbers.

Organically Acceptable Methods
Use cultural control in an organically certified crop, as well as organic insecticides.

Combinations of organic insecticides are more effective compared to standalone pesticide applications (see the treatment table for more information). Organic insecticides such as insecticidal soap and azadirachtin may be useful in combination with other organic insecticides but are not effective in standalone applications. Entomopathogenic fungi products such as those containing Beauveria bassiana are also available for Bagrada bug control and are most effective when used in combination with other insecticides.

Though sweet alyssum is sometimes planted along the edges of organic cole crop fields and later vacuumed to remove Bagrada bugs, this practice often leads to higher Bagrada bug numbers and greater damage, and does not provide reliable control.

Monitoring and Treatment Decisions
Neonicotinoid-treated seeds are the most effective control method of Bagrada bug in areas that are regularly infested with Bagrada bug. If transplanting in areas that harbor high numbers of Bagrada bug,
apply an insecticide before or immediately after transplanting to protect transplants from migrating Bagrada bug adults. In the low desert, it is often necessary to apply a systemic insecticide to the soil before transplanting, or to use a foliar application of a pyrethroid after transplanting to prevent excess damage from Bagrada bug.

Look for Bagrada bug the morning following transplanting, when sprinklers are off. For direct-seeded cole crops, begin looking for bugs as soon as one day after planting. If you find Bagrada bugs, apply an insecticide to the transplants or apply insecticide when direct-seeded cole crops emerge. Continue monitoring two to three times per week until the 5- to 6-leaf stage. After this time, most plants tolerate Bagrada bug feeding without significant injury or yield loss.

Use the following monitoring methods:
1. Monitor during the warmer times of the day (near or above 80°F).
2. Look for bugs on the undersides of cotyledons and leaves.
3. Look for damage on cotyledons and young leaves.
4. Look for weaker or drooping plants in the field.
5. Keep your eyes on the soil underneath plants, on stems at the soil surface, and in cracks in the soil.
6. Apply an insecticide if there are one or more Bagrada bug adults per 3-foot row of seedlings or transplants.
7. After insecticide application (if necessary), look carefully on the soil for dead bugs; bugs blend in with the soil and play dead when disturbed.

During stand establishment, apply a foliar insecticide in a narrow band (4 inches wide) over the seedlings. Apply over a short period of time at the end of an irrigation run to prevent dilution and avoid pushing the insecticide too deep into the soil.

When stands are established, apply an insecticide when bugs or fresh damage are readily observed. Use foliar sprays, especially those with residual efficacy, such as pyrethroids, methomyl, or neonicotinoids (such as clothianidin or dinofuran, which also protect against whiteflies) for extended Bagrada bug control.

Duration of control depends on application frequency, coverage, rates, whether tank-mix combinations are used, and the extent to which Bagrada bug continues to migrate into the field. Apply foliar insecticides during afternoon and early evening (only as is consistent with the pesticide label restrictions on times of application), when Bagrada bugs are most active. To help avoid the development of insecticide resistance, rotate applications among different insecticide modes of action.

<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>CLOTHIANIDIN (NipsIIt Vegetables)</td>
<td>Label rates</td>
<td>12</td>
<td>NA</td>
</tr>
</tbody>
</table>

MODE-OF-ACTION GROUP NUMBER‡: 4A

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**

A. CLOTHIANIDIN

Illustrated version at ipm.ucanr.edu/agriculture/cole-crops/
COMMENTS: Registered for use only on broccoli seeds in California, but seed treated in and obtained from another state can be legally used in California even if the chemical is not registered on the crop in California. Contact your retail seed dealer for information and availability. Application rate per seed depends on the amount of seed planted per acre.

**Foliar application**

A. **BIFENTHRIN**  
(Brigade 2EC)  
2.1–6.4 fl oz  
MODE-OF-ACTION GROUP NUMBER: 3A

B. **ZETA-CYPERMETHRIN**  
(Mustang)  
3.4–4.3 oz  
MODE-OF-ACTION GROUP NUMBER: 3A  
COMMENTS: In certain cole crops exported to Canada (broccoli, Brussels sprouts, cabbage, and cauliflower), PHI of 14 days is recommended in order to meet tolerances—see FIFRA 2(ee) recommendation for more information.

C. **LAMBDACYHALOTHIN**  
(Warrior II with Zeon Technology)  
1.28–1.92 oz  
MODE-OF-ACTION GROUP NUMBER: 3A  
COMMENTS: Registered for use on head and stem cole crops only (see label for more information). Add a wetting agent to improve coverage.

D. **BETA-CYFLUTHRIN**  
(Baythroid XL)  
2.4–3.2 fl oz  
MODE-OF-ACTION GROUP NUMBER: 3A

E. **CLOTHIANIDIN**  
(Belay)  
3–4 fl oz  
MODE-OF-ACTION GROUP NUMBER: 4A  
COMMENTS: Rates and PHI listed above are specific to foliar application. Foliar application not registered for use on crops grown for seed production. Highly toxic to bees for more than 5 days after an application. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

F. **DINOTEFURAN**  
(Scorpion 35SL)  
Foliar: 2–7 fl oz  
Soil: 9–10.5 fl oz  
MODE-OF-ACTION GROUP NUMBER: 4A  
COMMENTS: Registered for head and stem cole crops only (see label for more information). Not registered for vegetables grown for seed. Highly toxic to bees for more than 38 hours after an application. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

G. **IMIDACLOPRID**  
(Admire Pro)  
Foliar: 1.3 fl oz  
Soil: 4.4–10.5 fl oz  
MODE-OF-ACTION GROUP NUMBER: 4A  
COMMENT: Not registered for use on cole crops grown for seed. Highly toxic to bees. Not effective as a stand-alone application, but useful when followed with a pyrethroid immediately after emergence or immediately after transplanting. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.
H. METHOMYL*  
(Lannate LV)  
Label rates 48 See label  
MODE-OF-ACTION GROUP NUMBER: 1A  
COMMENTS: Not registered for use on broccoflower (cavalo), kohlrabi, mizuna, mustard spinach, or rape greens. Add a wetting agent to improve coverage.

I. NOVALURON  
(Rimon 0.83 EC)  
12 fl oz 12 7  
MODE-OF-ACTION GROUP NUMBER: 15  
COMMENTS: Registered for use in broccoli, Chinese broccoli, Brussels sprouts, broccoflower, cabbage, Chinese cabbage, cauliflower, Chinese mustard, and kohlrabi. Controls nymphs and can reduce the viability of Bagrada bug eggs but does not kill adult bugs. Consider tank mixing with an adulticide such as a pyrethroid or a neonicotinoid for further control.

Organic Options

A. SPINOSAD  
(Entrust SC)#  
8–10 fl oz 4 1  
MODE-OF-ACTION GROUP NUMBER: 5  
PLUS…  
PYRETHRINS  
(PyGanic Crop Protection EC 17 fl oz 12 0  
1.4 II)#  
MODE-OF-ACTION GROUP NUMBER: 3A  
PLUS (optional)…  
INSECTICIDAL SOAP  
(M-Pede)#  
0.25%–1% (by volume) solution 12 0  
MODE OF ACTION: A contact insecticide with smothering and barrier effects.  
OR…  
AZADIRACHTIN  
(Debug 3.0)#  
12–22.5 fl oz 4 0  
MODE-OF-ACTION GROUP NUMBER: un  
OR…  
BEAULERIA BASSIANA STRAIN GHA  
(Mycotrol ESO)#  
1 qt 4 0  
MODE-OF-ACTION GROUP NUMBER: biological (entomopathogenic fungi)  
COMMENTS: Combination of spinosad and pyrethrins is most effective option for organic growers. Other products listed here may provide additional control when used in combination with these two products. Azadirachtin and insecticidal soaps are not effective in stand-alone applications. If using insecticidal soap, solution should be less than 1% to avoid crop injury. Rate included above for PyGanic is based on efficacy research; however, higher rates may be necessary in organic systems (label allows 16 to 59 fl oz per acre of PyGanic in tank mixes). Mycotrol is not registered for use on broccoflower (cavalo), mizuna, and mustard spinach. Check with organic certifier to determine which products are organically acceptable.

B. SPINOSAD  
(Entrust SC)#  
8–10 fl oz 4 1  
MODE-OF-ACTION GROUP NUMBER: 5  
COMMENTS: Can provide some control as a stand-alone application, but most effective when used in combination with pyrethrins. Check with organic certifier to determine which products are organically acceptable.

C. PYRETHRINS
Bagrada Bug (12/20)

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(PyGanic Crop Protection EC 16–64 fl oz 12 0
1.4 II)#

MODE-OF-ACTION GROUP NUMBER#: 3A

COMMENTS: Does not provide residual control. Can provide some control as a stand-alone application, but most effective when used in combination with spinosad. Check with organic certifier to determine which products are organically acceptable.

‡ 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.

† 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 are assigned by IRAC (Insecticide Resistance Action Committee).

‡ Acceptable for use on organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.
BEET ARMYWORM (12/20)
Scientific Name: Spodoptera exigua

DESCRIPTION OF THE PEST
Beet armyworm caterpillars (larvae) vary in color, but are commonly olive green with a yellowish, lengthwise stripe on each side of the body. Often there is a dark spot on each side of the body above the second pair of true legs. The body surface is smooth and almost hairless. There are four pairs of prolegs (leglike appendages, or fleshy stubs) in the middle of the abdomen, on segments 3 to 6. Older larvae may be up to 1.5 inches long.

Adult moths lay their eggs in scale-covered, cottony masses on leaf surfaces. The first- and second-instar larvae tend to feed in groups near the egg mass, scraping the leaf surface, skeletonizing leaves and leaving veins largely intact, or completely consuming leaves. As they grow older, larvae disperse toward stems and the center of the plant and feed more individually.

Beet armyworms increase in numbers as weather warms and are most common on late-summer and fall crops.

DAMAGE
Beet armyworms can kill seedlings, consume large portions of leaves, and stunt growth by feeding on buds. However, serious economic damage to cole crops is uncommon.

MANAGEMENT
Use biological and cultural controls to suppress armyworm numbers. Monitor fields and field borders regularly from planting until heading.

Cultural Control
Use the following cultural methods to control beet armyworms:
- Disc fields immediately following harvest to kill larvae and pupae.
- Destroy weeds along field borders; armyworms often migrate from these areas into newly planted fields.

Biological Control
Many natural enemies attack beet armyworms. Common parasites include the wasps Chelonus insularis and Hyposoter exiguae, and the tachinid fly Lespesia archippivora. Consider installing insectary plants to attract natural enemies.

Entomopathogenic viral diseases may provide some control of beet armyworm. Though these viruses may occur naturally, natural occurrence is not likely to keep this pest below damaging numbers.

Organically Acceptable Methods
Use biological and cultural controls in an organically certified crop. Sprays of Bacillus thuringiensis and the Entrust SC formulation of spinosad are also organically acceptable.

Monitoring and Treatment Decisions
Start monitoring for beet armyworm before seedlings emerge. Frequently monitor seedlings, which are very susceptible to armyworm damage.
1. Check for egg masses and young larvae in pigweeds, lambsquarters, nettleleaf goosefoot, and other weeds surrounding the field. If numbers are high on weeds, watch carefully for infestations on crop seedlings.
2. Consider placing pheromone traps to monitor adults and predict egg laying.
3. Once seedlings emerge or right after transplanting, check plants at least twice per week for armyworm egg masses and young larvae. Sample for armyworms along with loopers and cabbageworms and include them in the total caterpillar count.

An insecticide application may be needed if one second- or third-instar beet armyworm is found for every 10 plants. However, it is usually not necessary to apply insecticide for armyworms on older plants (between thinning and heading). Apply insecticide just before heading if caterpillar numbers threaten to damage the heads.

Beet armyworms are more difficult to control with insecticides than loopers and cabbageworms, so note their presence in monitoring records. Additionally, beet armyworm has developed resistance to carbamate insecticides in some regions, such as the low desert.

<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>A. CHLORANTRANILIPROLE (Coragen)</td>
<td>3.5–7.5 fl oz</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Foliar application; use with an effective adjuvant for best performance. Use higher application rates within this range for heavier infestations, larger or denser crops, or extreme environmental conditions such as rainy weather or high temperatures.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. SPINETORAM (Radiant SC)</td>
<td>5–10 fl oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Not for yellowstriped armyworm and western yellowstriped armyworm control. Toxic against some natural enemies (predatory beetles, syrphid fly larvae, and predatory thrips) when sprayed and 5 to 7 days after. Control improved with addition of an adjuvant.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. BACILLUS THURINGIENSIS ssp. AIZAWAI (Agree WG)</td>
<td>0.5–2 lb</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 11A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Most effective against newly hatched larvae, so proper treatment timing is essential. Check with organic certifier to determine which products are organically acceptable.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. EMAMECTIN BENZOATE (Proclaim)</td>
<td>2.4–4.8 oz</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply more than 2 sequential applications of this product without rotating to a chemical with a different mode-of-action group number. Preharvest interval is 7 days for head and stem cole crops, and 14 days for leafy vegetables.</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.
E. **INDOXACARB**  
   (Avaunt)  
   MODE-OF-ACTION GROUP NUMBER: 22A  
   COMMENTS: Add a wetting agent to improve coverage.

F. **SPINOSAD**  
   (Entrust SC)#  
   MODE-OF-ACTION GROUP NUMBER: 5  
   COMMENTS: Toxic against some natural enemies (predatory beetles, syrphid fly larvae, and predatory thrips) when sprayed and 5 to 7 days afterward. Check with organic certifier to see which products are organically acceptable.

G. **METHOXYFENOZIDE**  
   (Intrepid 2F)  
   MODE-OF-ACTION GROUP NUMBER: 18  
   COMMENTS: For early-season applications, application rate is 4–8 fl oz per acre. For mid- to late-season applications and heavy infestations, application rate is 8–10 fl oz per acre.

H. **CRYOLITE**  
   (Prokil Cryolite 96)  
   MODE-OF-ACTION GROUP NUMBER: 8C  
   COMMENTS: Registered for use on broccoli, Brussels sprouts, cabbage, and cauliflower. Use on cabbage is allowed based on a supplemental label (EPA Reg. No. 10163-41). For broccoli, Brussels sprouts, and cauliflower, preharvest interval is 7 days. For cabbage, preharvest interval is 14 days. Must be ingested by the insect. Apply when young caterpillars are present. Can be useful in an insecticide resistance management program.

J. **METHOMYL**  
   (Lannate LV)  
   MODE-OF-ACTION GROUP NUMBER: 1A  
   COMMENTS: Not registered for use on broccoflower (cavalo), kohlrabi, mizuna, mustard spinach, or rape greens. Adversely affects natural enemies. Add a wetting agent to improve coverage.

† 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.

‡ 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 are assigned by IRAC (Insecticide Resistance Action Committee).

§ Acceptable for use on organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.
**BULB MITES** (12/20)

**Scientific Names:** *Rhizoglyphus* spp., *Tyrophagus* spp.

**DESCRIPTION OF THE PEST**

Bulb mites are shiny, creamy-white, bulb-shaped mites that range in size from 0.02 to 0.04 inches (0.5–1 mm) and look like tiny pearls with legs. They generally occur in clusters and inhabit damaged areas of the crop. Females lay about 100 eggs individually or in clusters. Larvae have three pairs of legs, while nymphs and adults have four pairs of brown legs.

Bulb mites have a wide host range, and feed on bulbs, roots, and tubers of various plant species. They can survive on decaying vegetation in the field until it is completely decomposed.

**DAMAGE**

Bulb mites can stunt plant growth and reduce stand density. They can attack germinating seedlings and deform their leaves, but are most commonly secondary pests that colonize damaged crop tissue. Primary damage from *Rhizoctonia* diseases, clubroot, or cabbage maggot can attract bulb mites.

This pest is most damaging in cool, wet weather, especially when there is undecomposed plant material in the soil. Though their damage is not widespread in California, they can be a problem for direct-seeded cole crops (especially broccoli) in the Salinas Valley. Bulb mites are not a pest of cole crops in the southern desert due to the hot, dry weather that occurs in that region.

**MANAGEMENT**

**Cultural Control**

Rapid rotation from one crop to the next fosters the survival of mites on leftover crop residue in the soil. Decaying cole crops, especially cauliflower, may harbor very high bulb mite numbers. To reduce mite damage:

- Allow complete decomposition of organic matter by leaving fields unplanted (fallow) between the harvest of the previous crop and the start of the next crop.
- Avoid consecutive plantings of cole crops and other *Brassica* crops, particularly those that are direct-seeded.
  - Except in the southern desert, where summer temperatures are too high to favor bulb mites.

**Monitoring and Treatment Decisions**

There are currently no specific monitoring methods for bulb mites. Use a stereoscope to examine fragments of undecayed vegetation in the soil for the presence of the mites.

The key to preventing bulb mites and their damage is to allow organic matter to completely break down before planting. No action thresholds currently exist, and pesticide applications for this pest are generally not necessary in cole crops. However, fumigation for other pests will also control bulb mites.
CABBAGE APHID (12/20)

Scientific Name: *Brevicoryne brassicae*

**DESCRIPTION OF THE PEST**

Cabbage aphids are greenish-gray with a white, waxy coating. They commonly occur in dense colonies. Adults can be winged or wingless; the winged adults have a black thorax.

Adult females give birth to nymphs throughout the year in much of California. Cabbage aphids have many generations per year.

**DAMAGE**

Cabbage aphids prefer to feed on the youngest leaves and flowering parts. They are also found deep within the heads of Brussels sprouts and cabbage. The aphid feeds only on plants in the family Brassicaceae (Cruciferae), including weedy mustards in and around fields.

Cabbage aphids do not commonly damage seedlings. Their numbers increase after thinning or transplanting, and large colonies then can stunt or kill small plants. Their most serious economic damage is contamination of the crop at harvest. Because leaves curl around where they feed in dense, waxy colonies, when aphids are abundant it is difficult to reach them with insecticide sprays.

**MANAGEMENT**

Conserve natural enemies that reduce cabbage aphids, but keep in mind that natural enemies may not provide sufficient control. Use cultural controls and well-timed insecticide application to reduce aphid numbers and avoid harming natural enemies of other pests.

Most fields in coastal cole crop production regions require at least one insecticide application before heading; however, insecticide application before heading is typically not necessary in the low desert. To conserve the parasites and predators of aphids and other pests, delay insecticide application as long as cabbage aphids do not threaten yield quality and quantity. Delay application until just before head formation to maintain natural enemies that can keep infestations of armyworms, cabbage loopers, diamondback moths, and imported cabbageworms below economically damaging numbers, therefore reducing the need for additional insecticide applications.

**Biological Control**

Many natural enemies can keep aphids at low or moderate numbers. However, if aphid infestations are severe or are located deep within heads, natural enemies may not provide adequate control.

Important natural enemies include the *Diaeretiella rapae* parasitic wasp, fungal pathogens, lady beetles, and syrphid fly larvae. Maintain hedgerows to sustain and provide refuge for natural enemies.

**Cultural Control**

Use the following cultural methods to control cabbage aphids:

- Destroy crop remnants immediately after harvest.
- Remove alternate hosts, such as mustards and related weeds around field borders.
- Be sure transplants are pest-free before taking them to the field. Infestations on Brussels sprouts can start in seedling beds.
- Remove and destroy infested plants in the field early in the crop cycle.
Organically Acceptable Methods
Use biological and cultural controls in an organically certified crop. Applications of organically acceptable insecticidal soap provide partial control. To increase effectiveness, spray the insecticidal soap during foggy conditions. Soap sprays may be phytotoxic when applied at higher concentrations, especially in Brussels sprouts and cabbage, so use lower rates to avoid crop injury (see the treatment table for more information).

Monitoring and Treatment Decisions
After seedling emergence or right after transplanting, check the field at least twice per week. Sample upwind of field borders and edges next to other crucifers first; this is where aphids tend to first appear.

- If no aphids are found, field samples may not be needed.
- If aphids are found, take field samples in a zigzag pattern.
- Be sure to check all blocks within the field, because aphid populations are often clumped.

Refer to the paragraphs below to make pesticide application decisions for different cole crops. After applying insecticide to control cabbage aphids, check fields frequently. Spray again if aphids reappear.

**Broccoli, Cabbage, and Cauliflower**
Before heading, check for cabbage aphid in the youngest, highest, and innermost leaves of young plants. Also check for natural enemies.

Until heading, broccoli and cauliflower crops can tolerate up to 100 aphids per plant. Because of the overlapping growth of their leaves, cabbage crops require more careful management and have less tolerance for aphids even during the early vegetative stages. Apply insecticide to cabbage as soon as 1 to 2% of cabbage plants are infested with one or more aphids.

After heading, check the flowering parts of broccoli and cauliflower, and pull back wrapper leaves of cabbage. Once heads begin to form, control cabbage aphids even if only a few are present.

**Brussels Sprouts**
Use presence-absence and sequential sampling (described below). This sampling method reduces the number of samples required to decide whether an application is necessary. It is based on whether any aphids are present on a leaf, not the number of aphids.

1. Divide the field into four blocks.
2. Randomly select 13 plants from each block that can be sprayed separately.
3. Take 5 samples along the field border and take the rest throughout the field.
4. For each plant, record if aphids are present or not.
5. Use the table below to determine the need for insecticide application or the need to continue sampling.
6. If you take 50 samples and still do not reach a decision, wait until the next sampling date to make a decision.

<table>
<thead>
<tr>
<th>#Plants sampled</th>
<th>Number of plants with aphids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do not treat</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
</tr>
</tbody>
</table>

Cabbage Aphid (12/20) 15
Illustrated version at ipm.ucanr.edu/agriculture/cole-crops/
Brussels sprouts can tolerate 40% infested plants from transplanting until 2 weeks before harvest. This table advises pesticide application at 15% infested plants and is conservative. At topping, apply an insecticide if 1 or 2% of plants are infested with one or more aphids. Insecticides are more effective after topping because coverage is greatly improved.

<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>A. SPIROTETRAMAT (Movento)</td>
<td>4–5 fl oz</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. FLUPYRADIFURONE (Sivanto 200 SL)</td>
<td>7–12 fl oz</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 4D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. ACETAMIPRID (Assail 30SG)</td>
<td>4 oz</td>
<td>12</td>
<td>See comments</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Rate included is based on efficacy research in broccoli (see label for additional information on application rates). For head and stem cole crops (broccoli, cauliflower, cabbage, Brussels sprouts, and others), PHI is 7 days. For leafy cole crops (kale, mizuna, broccoli raab, bok choy, mustard greens, and others), PHI is 3 days. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. CYANTRANILIPROLE (Exirel)</td>
<td>13.5–20.5 fl oz</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. FLONICAMID (Beleaf 50 SG)</td>
<td>2–2.8 oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Thorough coverage is necessary for optimal control.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. INSECTICIDAL SOAP (M-Pede)#</td>
<td>1–2% (v/v) solution</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION: A contact insecticide with smothering and barrier effects.</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.
COMMENTS: Provides only partial control. May be phytotoxic on Brussels sprouts and cabbage. Check with organic certifier to determine which products are organically acceptable.

G. PYMETROZINE
(Fulfill) 2.75 oz 12 7
MODE-OF-ACTION GROUP NUMBER: 9B
COMMENTS: Best used in a tank mix with another insecticide registered for aphids.

H. SULFOXAFLOR
(Sequoia) 1.5–2.0 fl oz 12 3
MODE-OF-ACTION GROUP NUMBER: 4C
COMMENTS: Not registered for use on cole crops grown for seed. Rates included are based on efficacy research in broccoli (see label for additional information on application rates). Use allowed under a Special Local Needs label (SLN No. CA-170004, expires March 31, 2022).

Organic Options (Efficacy research may be lacking on these products)

A. BEAUVERIA BASSIANA STRAIN GHA
(Mycotrol ESO)# 0.25–1 qt 4 0
MODE-OF-ACTION GROUP NUMBER: biological (entomopathogenic fungi)
COMMENTS: Not registered for use on broccoflower (cavalo), mizuna, and mustard spinach. More effective on aphid nymphs. When applied to soil, this fungus promotes cabbage growth by increasing nutrient absorption even when moisture is reduced. May not significantly reduce cabbage aphid when used as a standalone foliar application. Check with your organic certifier to see which products are organically acceptable.

AND...
AZADIRACHTIN
(AzaGuard)# 8 fl oz 4 0
MODE-OF-ACTION GROUP NUMBER: un
COMMENTS: Not registered for use on mustard spinach. Rate included above is based on efficacy research (label allows up to 22.5 fl oz per acre). Check with your organic certifier to see which products are organically acceptable.

† 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 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 are assigned by IRAC (Insecticide Resistance Action Committee).

‡ Acceptable for use on organically grown produce.
CABBAGE LOOPER (12/20)

Scientific Name: *Trichoplusia ni*

DESCRIPTION OF THE PEST

Cabbage looper larvae can be distinguished from most other caterpillars in cole crops by their distinctive looping movement. They move by arching the middle portion of their body and pulling their rear end forward to meet the front legs.

The caterpillars are green, usually with a narrow white stripe along each side and several narrow, pale lines down the back. They are smooth-skinned, with only a few long bristles down the back, and may grow to be up to 1.5 inches long.

Cabbage loopers have two pairs of prolegs (leglike appendages, or fleshy stubs) on the fifth and sixth abdominal segments (middle of the abdomen). This distinguishes them from imported cabbageworms, which have four pairs of mid-abdominal prolegs, on segments 3 to 6. True loopers have one pair of mid-abdominal prolegs, on segment 6.

Last-instar cabbage loopers pupate in a silken cocoon, usually attached to leaves. Adults (moths) are mottled brownish or gray with an 8-shaped, silvery marking on each front wing. Eggs are dome-shaped with numerous fine ridges and laid singly, mostly on the undersurface of leaves.

Cabbage looper has many generations per year and develops throughout the year in California cole crops. The highest numbers commonly occur during fall.

DAMAGE

Although seedlings are occasionally damaged, most injury occurs after heading. Loopers chew ragged holes in leaves and bore through and contaminate heads and leaves with their bodies and frass. Young plants between seedling stage and heading can tolerate substantial leaf damage without yield loss.

MANAGEMENT

Many natural enemies generally keep cabbage loopers below economically damaging levels at least until heading, unless they are disrupted by broad-spectrum insecticides applied for other pests. Monitor the abundance of loopers and natural enemies to determine whether biological control of cabbage looper is sufficient, and to determine whether insecticide application is needed after heading.

**Biological Control**

Important natural enemies include the egg-parasitic wasp *Trichogramma pretiosum*, the larval-parasitic wasps *Copidosoma truncatellum*, *Hyposoter exiguae*, and *Microplitis brassicae*, and a parasitic tachinid fly, *Voria ruralis*. A naturally occurring entomopathogenic virus is sometimes effective, turning infected caterpillars into elongate, dark, liquidy sacks that hang from leaves.

Consider maintaining hedgerows of insectary plants to attract natural enemies of cabbage loopers.

**Organically Acceptable Methods**

Use biological control and sprays of *Bacillus thuringiensis* and the Entrust SC formulation of spinosad in an organically certified crop.
Monitoring and Treatment Decisions

Combine the monitoring for cabbage looper and imported cabbageworm, beginning after seedling emergence or after transplanting.

1. Check 25 plants selected randomly throughout the field.
2. Look for eggs and small larvae on the underside of lower leaves.
3. If leaves have holes, search nearby for caterpillars, opening chewed heads if present.

Monitor for natural enemies when monitoring caterpillars. If looper numbers are close to the treatment threshold but there are many parasitized or diseased individuals, delay treatment for a few days. Pulling apart some apparently healthy caterpillars may reveal that they contain maggotlike parasite larvae not yet old enough to cause the caterpillar to appear parasitized. Monitor again in a few days to see whether natural enemies are reducing looper numbers.

The location and extent of chewing may indicate the presence of cabbage looper caterpillars and how numerous they may be. However, to make pesticide application decisions, use the combined number of counted healthy cabbage loopers and imported cabbageworms to decide whether insecticide application is necessary.

Apply insecticide:
- To seedlings or small plants, if the numbers of medium-to-large caterpillars are high enough (approximately 1 caterpillar per 5 plants) to stunt crop growth.
- To well-established plants and before heading or at Brussels sprouts formation, if more than 9 small-to-medium caterpillars are found per plant.
- At heading, if more than 1 nonparasitized or noninfected looper or other caterpillar is found in 25 plants.
- From heading to harvest, apply insecticide if more than 10% of the sampled plants (2–3 plants out of 25) are infested with at least 1 caterpillar.

If insecticide application is warranted, use the caterpillar-specific Bacillus thuringiensis to avoid damaging natural enemy populations. Bacillus thuringiensis and moderately selective insecticides (such as chlorantraniliprole and spinetoram) are very effective against cabbage looper and imported cabbageworm, especially when applied to early-instar (young) caterpillars. If significant numbers of other caterpillar species are present (see the beet armyworm and diamondback moth sections), apply an insecticide for these pests. Pesticide applications for other caterpillars, such as beet armyworm and diamondback moth, will also control cabbage looper.

### Common name (Example trade name) | Amount per acre | REI‡ (hours) | PHI‡ (days)
--- | --- | --- | ---
Bacillus thuringiensis ssp. kurstaki (Condor WP)# | 1–2 lb | 4 | 0

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. **Bacillus thuringiensis** ssp. *kurstaki* (Condor WP)#

*Mode-of-action group number*: 11A

*Comments*: Not registered for use on broccoflower (cavalo), mizuna, and mustard spinach. Label strongly recommends an approved spreader or sticker to improve durability in cole crops. Check with your organic certifier to determine which products are organically acceptable.
B. CHLORANTRANILIPROLE
   (Coragen)  
   3.5–7.5 fl oz  
   MODE-OF-ACTION GROUP NUMBER\(^{1}\): 28
   COMMENTS: Foliar application; use with an effective adjuvant for best performance. Use higher application rates within this range for heavier infestations, larger or denser crops, or extreme environmental conditions such as rainy weather or high temperatures.

C. SPINETORAM
   (Radiant SC)  
   5–10 fl oz  
   MODE-OF-ACTION GROUP NUMBER\(^{1}\): 5
   COMMENTS: Toxic against some natural enemies (predatory beetles, syrphid fly larvae, and predatory thrips) when sprayed and 5 to 7 days after. Control improved with addition of an adjuvant.

D. SPINOSAD
   (Entrust SC)#  
   3–6 fl oz  
   MODE-OF-ACTION GROUP NUMBER\(^{1}\): 5
   COMMENTS: Toxic against some natural enemies (predatory beetles, syrphid fly larvae, and predatory thrips) when sprayed and 5 to 7 days after. Check with your organic certifier to determine which products are organically acceptable.

E. METHOXYFENOZIDE
   (Intrepid 2F) See comments  
   MODE-OF-ACTION GROUP NUMBER\(^{1}\): 18
   COMMENTS: For early-season applications to young crop and small plants, apply 4–8 fl oz per acre. For mid-to late-season infestations and larger infestations, apply 8–10 fl oz per acre.

F. EMAMECTIN BENZOATE
   (Proclaim)  
   3.2–4.8 oz  
   MODE-OF-ACTION GROUP NUMBER\(^{1}\): 6
   COMMENTS: The preharvest interval is 7 days for head and stem crops, and 14 days for leafy cole crops.

G. INDOXACARB
   (Avaunt)  
   2.5–3.5 oz  
   MODE-OF-ACTION GROUP NUMBER\(^{1}\): 22A
   COMMENTS: Add a wetting agent to improve coverage.

H. CRYOLITE
   (Prokil Cryolite 96)  
   8–16 lb  
   MODE-OF-ACTION GROUP NUMBER\(^{1}\): 8C
   COMMENTS: Registered for use on broccoli, Brussels sprouts, and cauliflower. Use on cabbage is allowed by a supplemental label (EPA Reg. No. 10163-41). The preharvest interval for broccoli, Brussels sprouts and cauliflower is 7 days. For cabbage, the preharvest interval is 14 days. Must be ingested by the insect. Apply when young caterpillars are present. Can be useful in an insecticide resistance management program.

\(\dagger\) 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.

\(\dagger\) 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 are assigned by IRAC (Insecticide Resistance Action Committee).

\(\#\) Acceptable for use on organically grown produce.
CABBAGE MAGGOT (12/20)

Scientific Name: Delia radicum

DESCRIPTION OF THE PEST
Larvae of cabbage maggot are legless, white, and 0.4 inch long or less. Their head is pointed and the rear end is blunt with two brown, buttonlike spiracles encircled by short, fleshy outgrowths.

Adults are dark gray flies about one-half the size of the common house fly. Females are attracted to moist soils high in organic matter and lay their eggs in cracks in the soil. Hatching maggots burrow in the soil to feed beneath the soil surface. After 3 to 5 weeks, they form oblong, brown pupae in roots or soil. Cabbage maggots pupate for 2 to 4 weeks before emerging as adult flies.

There are at least two to three generations per year in coastal areas. In the central coast region, it is possible for cabbage maggot to have more than three generations per year. Cabbage maggots are not a pest in the southern desert. Their numbers increase during cool, wet weather.

Microscopic examination by a taxonomist is needed to distinguish cabbage maggot from other Delia spp., such as seedcorn maggot. Cabbage maggots typically infest direct-seeded cole crops about one month after planting, and infest transplanted cole crops within two weeks after planting. In contrast, seedcorn maggot infests only 1- to 2-week-old seedlings.

DAMAGE
Cabbage maggot feeding causes yellowing, stunting, slowed growth, and in some cases death of the plant. Cabbage maggots can destroy roots of any cole crop. When larvae are numerous, they riddle the roots with tunnels, providing entryways for bacterial soft rot and the pathogen that causes black leg. Though damage is usually restricted to the roots, heavy infestations can attack the flowering heads of cole crops.

Young plants, between seedling emergence until about one month after thinning or transplanting, are the most susceptible to damage. Plants that are attacked after they are well established can usually tolerate moderate infestations if they are otherwise healthy. Older plants may outgrow damage from moderate numbers of cabbage maggots if irrigation is carefully scheduled.

Brussels sprouts and cauliflower may be more susceptible than hybrid cultivars of broccoli, and crops planted in summer and fall suffer more damage than crops planted in other seasons.

MANAGEMENT
Manage cabbage maggot with a combination of cultural control and insecticide application.

Cultural Control
Use the following cultural methods to suppress cabbage maggot:

- Avoid hardening transplants near infested fields.
- Schedule irrigation carefully to allow older plants to outgrow maggot damage. Use the online decision support tool CropManage to keep track of irrigation.
- Disc under crop residues immediately after harvest; otherwise, some maggots can survive in residue and develop into adults.
• Avoid successive planting of *Brassica* crops, especially those planted within one month of a previous *Brassica* crop.
• Allow crop residue to dry and decompose completely.

**Monitoring and Treatment Decisions**

Pull up affected plants and check roots and soil to confirm the presence of maggots. If several rows of seedlings are infested, plants may be removed and rows replanted. If the roots are tunneled but no maggots are present, maggots have left roots to pupate in the soil. In this case, insecticide application will not be effective.

For spring plantings where cabbage maggot causes economic injury, use a delayed insecticide application to prevent intolerable damage from this pest. The timing of this application is critical; an insecticide applied two to three weeks (two weeks for cole crops that grow more quickly) after direct seeding more effectively controls these maggots than does a traditional at-plant insecticide application. Insecticide applied later than the seedling stage may not control cabbage maggot.

For direct-seeded crops in the Central Coast region, seed treatment with clothianidin can effectively control cabbage maggot.

<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>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.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Seed Treatment**

A. **CLOTHIANIDIN**  
   (NipsIt Vegetables)  
   Label rates  
   MODE-OF-ACTION GROUP NUMBER‡: 4A  
   COMMENTS: Registered for use only on broccoli seeds in California, but seed treated in and obtained from another state can be legally used in California even if the chemical is not registered on the crop in California. Effectively controls cabbage maggot in direct-seeded broccoli in the Central Coast region. Contact your retail seed dealer for information and availability. Application rate per seed depends on the amount of seed planted per acre.

**Foliar Application**

A. **CLOTHIANIDIN**  
   (Belay)  
   3–4 fl oz  
   MODE-OF-ACTION GROUP NUMBER‡: 4A  
   COMMENTS: Highly toxic to bees for more than 5 days after an application. Application rate and PHI above are for a foliar application. Use as a directed, banded foliar application applied to the base of affected plants. Foliar application not registered for use on cole crops grown for seed production. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

B. **ZETA-CYPERMETHRIN**  
   (Mustang)  
   2.4–4.3 fl oz  
   MODE-OF-ACTION GROUP NUMBER‡: 3A
COMMENTS: Use as a directed, banded foliar application applied to the base of affected plants. In certain cole crops exported to Canada (broccoli, Brussels sprouts, cabbage, and cauliflower), PHI of 14 days is recommended in order to meet tolerances—see FIFRA 2( ee) recommendation for more information.

C. LAMBDA-CYHALOTHRIN  
(Warrior II with Zeon Technology)  
MODE-OF-ACTION GROUP NUMBER: 3A  
COMMENTS: Registered for use on head and stem cole crops only (see label for more information). Use as a directed, banded foliar application applied to the base of plants.

D. CYANTRANILIPROLE  
(Verimark)  
MODE-OF-ACTION GROUP NUMBER: 28  
COMMENTS: Best insecticide option for transplants. Apply as a seedling tray drench.

E. PYRETHRINS  
(PyGanic Crop Protection EC 1.4 II)  
MODE-OF-ACTION GROUP NUMBER: 3A  
COMMENTS: Provides moderate control. Check with organic certifier to determine which products are organically acceptable.

‡ 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 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 are assigned by IRAC (Insecticide Resistance Action Committee).

# Acceptable for use on organically grown produce.
**CUTWORMS** (12/20)

**Scientific Names:**
- Black cutworm: *Agrotis ipsilon*
- Glassy cutworm: *Apamea (=Crymodes) devastator*
- Granulate cutworm: *Feltia subterranea*
- Variegated cutworm: *Peridroma saucia*

**DESCRIPTION OF THE PEST**

Cutworm larvae vary in color, but commonly
- are dull gray to brown caterpillars with various markings,
- blend in with the soil, and
- appear smooth-skinned at a distance.

Cutworm larvae have four pairs of prolegs (leglike appendages, or fleshy stubs) in the middle of the abdomen, on segments 3 to 6. Full-grown caterpillars are 1 to 2 inches long. Cutworms commonly curl up into a C-shape when disturbed.

Distinguishing characteristics of different cutworm larvae:
- Black cutworm is gray to dark brown on top with pale lengthwise stripes. It has an overall greasy appearance and numerous tiny, black, rounded, pebblelike bumps.
- Glassy cutworm is shiny, pale green to gray, or whitish with a brown head.
- Granulate cutworm is brownish to dark gray with black blotches or specks.
- Variegated cutworm is dark gray with a light stripe on the side and small yellow to orange spots on top of the abdomen.

Adult moths have dark gray or brown front wings with irregular spots or bands and pale hind wings. Females lay hundreds of white eggs, either singly or in clusters (depending on the species). Eggs are laid on leaves or stems close to the ground. After hatching, young larvae chew on the leaf surfaces. Larvae are nocturnal: older larvae drop to the ground and tunnel into the soil during the day and emerge at night to feed.

**DAMAGE**

Cutworms normally feed close to the soil surface, clipping off seedlings or chewing leaves that touch the ground. Uncommonly, cutworms bore into cabbage heads. Most feeding occurs at night; during the day cutworms are usually found just below the soil surface or under dirt clods.

Seedlings and young plants are cut off at or just below ground level; often several plants in a row will be wilted or clipped. Losses can be especially severe in fields that were recently thinned or that were precisely direct-seeded to a stand to eliminate the need for thinning. Damage often recurs in the same fields and same parts of fields year after year. Damage is worst when large numbers of cutworms are present before planting.

**MANAGEMENT**

Cutworms migrate into crops from surrounding weeds or infested crops. Monitor for cutworms in surrounding weeds. Use cultural controls and apply insecticide bait before seedling emergence or transplanting.
Biological Control
Cutworms have numerous natural enemies, including predatory beetles, parasitic wasps, and parasitic tachinid flies. However, natural enemy numbers are usually not high enough to control both cutworms and the other caterpillar pests that occur in the crop simultaneously. Biological control from these natural enemies is typically not sufficient to prevent economic damage.

Cultural Control
At least 10 days before planting:
- Remove weeds from field margins, and
- Plow fields to destroy egg-laying sites, food sources, larvae, and pupae.

Organically Acceptable Methods
Start with cultural control in an organically certified crop. Sprays of *Bacillus thuringiensis* and the Seduce formulation of spinosad are also available for cutworm control in organically grown cole crops.

Monitoring and Treatment Decisions
Before seedling emergence or transplanting, monitor for cutworms on weeds around field edges. Scout specifically along cracks and the crown area of plants, as cutworms typically hide in these places during the day. If many cutworms are present, apply insecticide bait. This controls most species (except the glassy cutworm, which occurs in the southern San Joaquin Valley). Baits are more effective when few plants are present, so apply bait after weed removal and before crop emergence or transplanting.

After seedling emergence or right after transplanting, check the crop for four or more wilted plants in a row with clipped or partially cut stems. Dig around those stems and sift the soil. If you find cutworms, apply insecticide.

When plants are small or young, monitor weekly or more often depending on the severity of the infestation. Apply insecticide as soon as several severed plants in the same row are found. A directed spray at the base of plants is most effective, but a broadcast spray can also be effective.

Spray for cutworms during the late afternoon or evening, so that cutworms will be exposed to insecticide when they emerge in the evening. Certain insecticides degrade when exposed to sunlight; insecticides applied earlier in the day may not be as effective at controlling cutworms as those applied in the late afternoon or evening.

### Common name (Example trade name) | Amount per acre | REI‡ (hours) | PHI‡ (days)
---|---|---|---
A. **CHLORANTRANILIPROLE** (Coragen) | 3.5–7.5 fl oz | 4 | 3

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. **CHLORANTRANILIPROLE** (Coragen) | 3.5–7.5 fl oz | 4 | 3

Comments: Foliar application; use with an effective adjuvant for best performance. Use higher application rates within this range for heavier infestations, larger or denser crops, or extreme environmental conditions such as rainy weather or high temperatures.
<table>
<thead>
<tr>
<th></th>
<th>INSECTICIDE NAME</th>
<th>TRADE NAME</th>
<th>RATE</th>
<th>PHI</th>
<th>MODE-OF-ACTION GROUP NUMBER</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.</td>
<td>METHOXYPENZIDE</td>
<td>Intrepid 2F</td>
<td>4</td>
<td>1</td>
<td>18</td>
<td>For suppression. Apply 4 to 8 fl oz per acre for early-season applications to young crops. Apply 8 to 10 fl oz per acre for mid- to late-season infestations and heavier infestations.</td>
</tr>
<tr>
<td>C.</td>
<td>CARBARYL</td>
<td>Sevin 5 bait</td>
<td>40 lb</td>
<td>12</td>
<td>1A</td>
<td>For treatments around the field where cutworms may migrate from weeds or other crops. PHI is 3 days for broccoli, cauliflower, cabbage, Brussels sprouts, and kohlrabi. PHI is 14 days for Chinese cabbage, collards, kale, and mustard greens.</td>
</tr>
<tr>
<td>D.</td>
<td>ESFENVALERATE</td>
<td>Asana XL</td>
<td>5.8–9.6 fl oz</td>
<td>12</td>
<td>3A</td>
<td>Registered for use in broccoli, Chinese broccoli, cabbage, cauliflower, collards, kohlrabi, mustard greens, and tight-heading varieties of Chinese cabbage (napa cabbage). For collard greens and mustard greens, PHI is 7 days. For other registered cole crops, PHI is 3 days.</td>
</tr>
<tr>
<td>E.</td>
<td>INDOXACARB</td>
<td>Avaunt</td>
<td>2.5–3.5 oz</td>
<td>12</td>
<td>22A</td>
<td>Add a wetting agent to improve coverage.</td>
</tr>
<tr>
<td>F.</td>
<td>METHOMYL*</td>
<td>Lannate LV</td>
<td>1.5 pt</td>
<td>48</td>
<td>1A</td>
<td>Not registered for use in broccoflower, kohlrabi, mizuna, mustard spinach, or rape greens. Add a wetting agent to improve coverage.</td>
</tr>
<tr>
<td>G.</td>
<td>SPINOSAD</td>
<td>Seduce</td>
<td>20–44 lb</td>
<td>4</td>
<td>5</td>
<td>Bait that targets cutworms. Check with organic certifier to determine which products are organically acceptable.</td>
</tr>
<tr>
<td>H.</td>
<td>BACILLUS THURINGIENSIS ssp. KURSTAKI</td>
<td>Deliver</td>
<td>0.25–1.5 lb</td>
<td>4</td>
<td>11</td>
<td>Check with organic certifier to determine which products are organically acceptable.</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.

† 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 are assigned by IRAC (Insecticide Resistance Action Committee).

# Acceptable for use on organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.
DARKLING BEETLES  (12/20)
Scientific Names: *Blapstinus* spp., *Coelus* spp.

DESCRIPTION OF THE PEST
Darkling beetles are dull, bluish black or brown beetles that clip off seedlings or feed on foliage. They may be distinguishable from beneficial predaceous ground beetles by the trochanters at the base of their hind legs, which can be seen by examining the undersides of adults. Predaceous ground beetles have enlarged trochanters, while the basal segment of darkling beetle legs is not enlarged. Predaceous ground beetles are usually shiny and sometimes have colorful markings, unlike the dull coloration of darkling beetles.

DAMAGE
Damage is similar to that caused by cutworms: seedlings are chewed off at the base and foliage may also be chewed. Damage usually begins at field edges as beetles come in from alfalfa, cover crops, or weedy areas. Feeding occurs primarily in the evening and night.

MANAGEMENT
Cultural Control
In the low desert, use transplants instead of direct seeding to prevent most damage from darkling beetles.

In the Central Valley, allow organic matter in the soil to completely decompose before planting cole crops to avoid attracting darkling beetles. (Note, however, that darkling beetles are not as great of a problem in cole crops in the Central Valley as they are in the low desert.)

Monitoring and Treatment Decisions
Before crop seedling emergence or transplanting, monitor for darkling beetles under weeds around field edges.

If darkling beetle infestations are expected or a persistent problem in the field, place insecticide bait around field edges before planting. In the low desert, darkling beetles are controlled by insecticide applications (usually with a pyrethroid) injected into the sprinkler irrigation water either before planting or at planting. Pyrethroid applications for Bagrada bug will also control darkling beetles.

Organically Acceptable Methods
Use cultural control in an organically certified crop.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Example trade name)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CARBARYL</td>
<td>40 lb</td>
<td>12</td>
<td>See comments</td>
</tr>
<tr>
<td>(Sevin 5 bait)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 1A</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. CARBARYL
(Sevin 5 bait) 40 lb 12 See comments

Illustrated version at http://ipm.ucanr.edu/agriculture/cole-crops/
COMMENTS: Not registered for use in mizuna, mustard spinach, and rape greens. For broccoli, Brussels sprouts, cabbage, cauliflower, and kohlrabi, PHI is 3 days. For Chinese cabbage, collards, kale, and mustard greens, PHI is 14 days.

B. ZETA-CYPERMETHRIN
(Mustang) 3.4–4.3 fl oz 12 See comments
MODE-OF-ACTION GROUP #: 3A
COMMENTS: In certain cole crops exported to Canada (broccoli, Brussels sprouts, cabbage, and cauliflower). PHI of 14 days is recommended in order to meet tolerances—see FIFRA 2(ee) recommendation for more information.

C. ESFENVALERATE
(Asana XL) 5.8–9.6 12 See comments
MODE-OF-ACTION GROUP #: 3A
COMMENTS: Registered for use in broccoli, Chinese broccoli, cabbage, cauliflower, collards, kohlrabi, mustard greens, and tight-heading varieties of Chinese cabbage (napa cabbage). For collard greens and mustard greens, PHI is 7 days. For other registered cole crops, PHI is 3 days. Do not use if leafminers are present.

D. PERMETHRIN
(Perm-Up 25DF) Label rates 12 See comments
MODE-OF-ACTION GROUP #: 3A
COMMENTS: Do not use if leafminers are present. Registered for use in broccoli, Brussels sprouts, cabbage, certain types of Chinese cabbage (see label) cauliflower, and collards.

E. CLOTHIANIDIN
(Belay) 9–12 fl oz 12 See comments
MODE-OF-ACTION GROUP #: 4A
COMMENTS: Use as a preplant or at-plant soil application (rate and PHI included above are for soil application only). Highly toxic to bees for more than 5 days after an application. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

F. DIAZINON
(Diazinon 50W) Label rates 96 (4 days) NA
MODE-OF-ACTION GROUP #: 1B
COMMENTS: Preplant or transplant water application only (see label for more information). Not registered for use on kohlrabi, mizuna, mustard spinach, and rape greens. Avoid drift and tailwater runoff into surface waters.

‡ 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 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 are assigned by IRAC (Insecticide Resistance Action Committee).
DIAMONDBACK MOTH (12/20)

Scientific Name: Plutella xylostella

DESCRIPTION OF THE PEST
Diamondback moth larvae (caterpillars) grow to be up to 0.3 inch long. They are wider in the middle and taper at both ends. The two prolegs on the last segment form a distinctive V-shape at the rear end. When disturbed, the caterpillars wriggle rapidly or attach themselves to a leaf by a silken thread and drop off, similar to the behavior of leafroller caterpillars. Mature diamondback moth caterpillars are smaller than other caterpillars that are common in cole crops.

The caterpillars mature in 10 to 14 days during warm weather and spin a loose cocoon and pupate on leaves or stems. Female adults (moths) lay tiny, roundish eggs singly on the undersides of leaves. Eggs are difficult to find.

Diamondback moth may be active throughout the year, especially in coastal areas. The pest is most numerous in spring to early summer and in the fall.

DAMAGE
Larvae feed mostly on outer or older leaves of plants. Young stages rasp the undersides of the leaves, creating damage with a characteristic “window paning” appearance, in which the upper surface of the leaf remains intact and becomes transparent. Older larvae chew small holes or feed at the growing points of young plants and chew floral stalks and flower buds.

Diamondback moth infestations are most serious when they damage the crowns or growing points of young plants or Brussels sprouts. This injury can severely stunt growth. Sometimes the caterpillars bore into flower buds or broccoli and cauliflower heads, causing contamination and economic injury. Injury to leaves alone is not usually serious, except when the wrapper or cap leaves of cabbage are injured.

MANAGEMENT
Keep records of diamondback moth while monitoring for other caterpillars. Natural enemies and insecticides applied to control other pests might keep the diamondback moth under control in most fields in California. Keep in mind that broad-spectrum pesticides applied for other pests can sometimes increase diamondback moth infestations by eliminating natural enemies.

Cultural Control
Rotate out of cole crops so that they do not grow in the same field in consecutive years. Plant all cole crops in a given field at the same time, rather than staggering planting dates between adjacent blocks of the same field. Blocks with differently aged cole crops enable diamondback moth to move through the field and cause sustained, continuous damage.

Biological Control
Natural enemies often control diamondback moth in California. In Southern California, an ichneumonid wasp, Diadegma insularis, is the most common parasitic wasp that attacks diamondback moth. Trichogramma pretiosum, another type of parasitic wasp, may also attack the moth eggs. Predators such as ground beetles, spiders, syrphid fly larvae, and true bugs can also play an important role in biological control of diamondback moth. Naturally occurring microbial diseases are not known to effectively control this pest. Consider planting insectary plants to attract natural enemies of diamondback moth.
Organically Acceptable Methods
Use biological control in an organically certified crop, as well as sprays of *Bacillus thuringiensis* and the Entrust SC formulation of spinosad.

Monitoring and Treatment Decisions
Twice per week during the following periods, sample fields for caterpillars and record the number of diamondback moth larvae separately from other species:
- during the seedling stage or right after transplanting,
- at thinning, and
- just before heading.

In cabbage, regularly monitor wrapper leaves for damage after heading. Adults frequently migrate in from fields being harvested or disc'd, so carefully check border rows if numbers were high in adjacent fields.

No economic thresholds have been developed for diamondback moth in California. Insecticide application may be necessary if there is significant feeding on growing points.

Diamondback moth has developed resistance to multiple insecticides with different modes of action. Therefore, it is especially important to rotate insecticide modes of action to manage this pest. Do not apply more than two insecticides with the same mode of action within a 10- to 14-day period.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. SPINOSAD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Entrust SC)‡</td>
<td>1.5–4 fl oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>(Success)</td>
<td>1.5–4 fl oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Toxic against some natural enemies (predatory beetles, syrphid fly larvae, and predatory thrips) when sprayed and 5 to 7 days after. Use the Entrust SC formulation of spinosad for organic production. Check with organic certifier to determine which products are organically acceptable.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **B. SPINETORAM**            |                 |              |             |
| (Radiant SC)                 | 5–10 fl oz      | 4            | 1           |
| MODE-OF-ACTION GROUP NUMBER: 5 |                 |              |             |
| COMMENTS: Toxic against some natural enemies (predatory beetles, syrphid fly larvae, and predatory thrips) when sprayed and 5 to 7 days after. Control improved with addition of an adjuvant. |

| **C. CHLORANTRANILIPROLE**   |                 |              |             |
| (Coragen)                    | 3.5–7.5 fl oz   | 4            | 3           |
| MODE-OF-ACTION GROUP NUMBER: 28 |                 |              |             |
| COMMENTS: Foliar application; use with an effective adjuvant for best performance. Diamondback moth has developed resistance to this active ingredient in some areas. Local populations may remain susceptible; in such cases it is important to maintain that susceptibility by using practices to prevent resistance development, including the rotation of insecticide modes of action every 10 to 14 days. Furthermore, do not |
apply to any generation of diamondback moth more than twice, or apply more than twice within a 30-day period (see the label for further information). Use higher application rates within this range for heavier infestations, larger or denser crops, or extreme environmental conditions such as rainy weather or high temperatures.

D. EMAMECTIN BENZOATE
(Proclaim) 2.4–4.8 oz 12 See comments
MODE-OF-ACTION GROUP NUMBER: 6
COMMENTS: PHI is 7 days for head and stem cole crops, 14 days for leafy cole crops.

E. INDOXACARB
(Avaunt) 3.5 oz 12 3
MODE-OF-ACTION GROUP NUMBER: 22A
COMMENTS: Add a wetting agent to improve coverage.

F. METHOMYL*
(Lannate LV) Label rates 48 See label
MODE-OF-ACTION GROUP NUMBER: 1A
COMMENTS: Not registered for use in broccoflower, kohlrabi, mizuna, mustard spinach, or rape greens. Application rate for diamondback moth in most crops is 1.5–3 pints per acre; consult the label for more information. Add a wetting agent to improve coverage. Adversely affects natural enemies of other pests.

G. METHOXYFENOZIDE
(Intrepid 2F) 12–16 fl oz 4 1
MODE-OF-ACTION GROUP NUMBER: 18
COMMENTS: For suppression only.

H. BACILLUS THURINGIENSIS ssp. KURSTAKI
(Condor WP)# 1–2 lb 4 0
MODE-OF-ACTION GROUP NUMBER: 11A
COMMENTS: Not registered for use on broccoflower (cavalo), mizuna, and mustard spinach. Diamondback moth may be resistant to *Bacillus thuringiensis* in some areas. If such resistance is not yet a problem, this insecticide is useful as long as it is rotated with other modes of action in order to prevent resistance development. Check with organic certifier to determine which products are organically acceptable. Label strongly recommends an approved spreader-sticker for application in cole crops.

‡ 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 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 are assigned by IRAC (Insecticide Resistance Action Committee).

# Acceptable for use on organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.
FLEA BEETLES (12/20)

Scientific Names: 
- Palestriped flea beetle: *Systena blanda*
- Striped flea beetle: *Phyllotreta striolata*
- Western black flea beetle: *Phyllotreta pusilla*
- Western striped flea beetle: *Phyllotreta ramosa*

DESCRIPTION OF THE PEST
Flea beetle adults are about 0.13 inch (3 mm) long, shiny, hard beetles. Adults have an enlarged basal segment (femur) on their hind legs, which is used to jump when disturbed. Species differ in color and markings. Larvae are pale and slender. They are most common in spring but can occur any time, especially in fields that are weedy or surrounded by weeds.

DAMAGE
Flea beetles are occasional pests of cole crop seedlings. The adults feed on the underside of leaves, creating small pits or irregularly shaped holes. High numbers of adults can kill or stunt seedlings, which can be economically damaging. Damage to older plants rarely causes economic loss, although their lower, older leaves may have been chewed and damaged.

Larvae do not cause economic damage but can mine leaves or feed on roots.

MANAGEMENT
Use cultural control to prevent flea beetle damage, and regularly monitor crop seedlings and young plants for flea beetles and their damage to help determine whether insecticide application is needed.

Cultural Control
Remove weeds along field margins to prevent adult flea beetles from moving into the crop from weeds.

Organically Acceptable Methods
Use cultural controls in an organically certified crop. Insecticidal soaps sprayed at the cotyledon stage may provide partial control.

Monitoring and Treatment Decisions
Check seedlings and new transplants in the field for flea beetle damage twice per week until plants are well established.

Low numbers can cause economic damage when plants are in the cotyledon or first-leaf stage. Apply an insecticide if several rows are damaged; spot treatment of outside rows or borders may be sufficient. Insecticide baits are not effective. If numbers are high, apply an insecticide to infested fields just before thinning to prevent post-thinning damage.

Once plants have 5 leaves, they can tolerate several beetles per plant without damage. Older plants are even more tolerant. One insecticide application should provide sufficient control.

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

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Mode of Action</th>
<th>Application Rate</th>
<th>PHI</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Carbaryl* (Sevin 4F)</td>
<td>0.5–1 qt</td>
<td>12</td>
<td>See comments</td>
<td></td>
</tr>
<tr>
<td>B. Esfenvalerate (Asana XL)</td>
<td>5.8–9.6 fl oz</td>
<td>12</td>
<td>See comments</td>
<td></td>
</tr>
<tr>
<td>C. Insecticidal Soap (M-Pede)</td>
<td>1–2% (v/v) solution</td>
<td>12</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>D. Cryolite (Prokil Cryolite 96)</td>
<td>8–16 lb</td>
<td>12</td>
<td>See comments</td>
<td></td>
</tr>
<tr>
<td>E. Thiamethoxam (Platinum)</td>
<td>5–11 fl oz</td>
<td>12</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>F. Imidacloprid (Admire Pro)</td>
<td>1.3 fl oz</td>
<td>12</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>G. Dinotefuran (Venom)</td>
<td>4 oz</td>
<td>12</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

*Not registered for use on crops grown for seed. Thiamethoxam and its metabolites (which include the neonicotinoid clothianidin) are highly toxic to bees. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

Illustrated version at ipm.ucanr.edu/agriculture/cole-crops/
### H. ACETAMIPRID

<table>
<thead>
<tr>
<th>Product</th>
<th>Mode of Action</th>
<th>Rates</th>
<th>PHI</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assail 30SG</td>
<td>4A</td>
<td>Label</td>
<td>12</td>
<td>See comments</td>
</tr>
<tr>
<td>Assail 70WP</td>
<td></td>
<td>Label</td>
<td>12</td>
<td>See comments</td>
</tr>
</tbody>
</table>

**Mode-of-Action Group Number**: 4A

**Comments**: Maximum application rate varies between head and stem cole crops and leafy cole crops. For head and stem cole crops, PHI is 7 days. For leafy cole crops, PHI is 3 days. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

‡ 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 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 are assigned by IRAC (Insecticide Resistance Action Committee).

‡ Acceptable for use on organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.
GARDEN SYMPHYLAN (12/20)
Scientific Name: Scutigerella immaculata

DESCRIPTION OF THE PEST
Garden symphylan, also called garden centipede, is closely related to insects. Symphylans are slender, elongate, and white with prominent, long antennae. When full grown, they are 0.5 inch long or less and have 15 body segments and 11 to 12 pairs of legs. They may be found more than 3 feet below the surface of the soil.

DAMAGE
Symphylans may damage sprouting seeds, seedlings before or after emergence, or older plants. They feed primarily on root hairs and rootlets. Feeding may stunt transplants as new roots grow out of the transplant plug.

The economic significance of symphylan feeding decreases as plants get larger and older. However, their pitting of roots may provide entry for pathogens, regardless of plant age.

Symphylan damage mainly occurs in well-drained soils with high content of organic matter, and especially in farms that fertilize with manures. Symphylans do not thrive in compacted or sandy soils.

MANAGEMENT
Reduce organic matter input. Monitor where symphylans have previously been a problem to determine the need for spot treatments.

Biological Control
Numerous organisms prey on symphylans, including predatory mites, predaceous ground beetles, true centipedes, and various fungi, but little is known about their effect on symphylan abundance. Consider installing and maintaining insectary plants to attract natural enemies of garden symphylans.

Cultural Control
The effectiveness of rotations with nonhost crops has not been studied; however, you can use the following cultural methods to prevent and control damage from garden symphylans:
- Reduce the amount of nondecomposed plant material and manure that is applied to the soil.
- Wait to seed or transplant until the cover crop, soil-incorporated weeds, and manure have completely broken down.
- Pack down the soil surface after planting to reduce crop injury.
- Plant a higher seed population in problem areas to help compensate for damage.

Organically Acceptable Methods
Use cultural control in an organically certified crop.

Monitoring and Treatment Decisions
Visual detection of any symphylans before or at planting often indicates that symphylans are numerous enough to cause economic damage. Bait trapping is a relatively efficient and easy sampling method. Before planting, use bait trapping to monitor garden symphylans by using the procedure described below:
1. Cut raw beets, carrots, or potatoes in half, in the way that exposes the most inside surface area, or in thick slices. Scratch the cut surface immediately before placing it at a depth where moisture is clearly visible in the soil. Use at least one dozen bait traps in a 10- to 15-acre field.
   - Remove dry soil from the surface with care; do not disturb the pores in the moist soil, through which symphylans move to reach the bait. Rake the dry soil away with a lettuce knife, rather than slicing into the soil with a knife or spade.

2. Cover each bait trap with a solid plastic cup or small plastic pot.
   - Make sure the plastic cap or dome is large enough to prevent excessive heating of the bait or accumulation of excess condensation. A round, white, plastic pot or Styrofoam cup about 6 inches in diameter and 6 inches deep, with no drainage holes, is adequate.

3. After 24 to 36 hours, remove the cover and count the symphylans, first on the soil surface underneath (symphylans will quickly hide), and then on the beet, carrot, or potato slice.

If any symphylans are present on the bait, significant stand loss can occur. Apply insecticide if any symphylans are detected on the bait. This will kill symphylans near the surface and allow the crop to better establish their roots.

Spot treatments with insecticide may be adequate. However, symphylans deeper in soil will eventually reinfest the root zone. If cultural methods and insecticide application are not enough to avoid damage, consider preplant soil fumigation.

<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>BIFENTHRIN (Brigade WSB)</td>
<td>Label rates</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Registered for use on head and stem cole crops only (see label for more information).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLOTHIANIDIN (Belay)</td>
<td>9–12 fl oz</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Soil application. Highly toxic to bees for more than 5 days following an application. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZETA-CYPERMETHRIN (Mustang)</td>
<td>2.4–4.3 fl oz</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: In certain cole crops exported to Canada (broccoli, Brussels sprouts, cabbage, and cauliflower), PHI of 14 days is recommended in order to meet tolerances—see FIFRA 2(ee) recommendation for more information.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AZADIRACHTIN (Aza-Direct)#</td>
<td>Label rates</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: un</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.
COMMENTS: Use a rate of 1–2 pints per acre under most circumstances. For heavy infestations, 3.5 pints per acre is allowed. Check with your organic certifier to see which azadirachtin products are organically acceptable.

E. ETHOPROP
(Mocap EC) 2.4 fl oz per 1000 ft row See label NA
MODE-OF-ACTION GROUP NUMBER: 1B
COMMENTS: Registered for use in cabbage only. At-plant application only. To avoid crop injury, do not use as a furrow treatment or allow the spray to contact the seed.

F. DIAZINON
(Diazinon 50W) Label rates 96 (4 days) NA
MODE-OF-ACTION GROUP NUMBER: 1B
COMMENTS: Registered for use in broccoli, Brussels sprouts, cauliflower, collards, kale, and mustard greens. Preplant or transplant water application only (see label for more information). Avoid drift and tailwater runoff into surface waters.

‡ 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.

† 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 are assigned by IRAC (Insecticide Resistance Action Committee).

§ Acceptable for use on organically grown produce.
GREEN PEACH APHID AND TURNIP APHID (12/20)

**Scientific Names:**
- Green peach aphid: *Myzus persicae*
- Turnip aphid: *Lipaphis erysimi*

**DESCRIPTION OF THE PEST**
In addition to cabbage aphid, the green peach aphid and turnip aphid can also infest cole crops. In the low desert, they are more common than cabbage aphid. However, in coastal areas, turnip aphid is rare and green peach aphid is less common than cabbage aphid.

The green peach aphid adults and nymphs are pale green to yellowish, and some individuals may be pinkish. The frontal tubercles at the base of the antennae are prominent and convergent on adults, which can be winged or wingless. Winged green peach aphids also have a distinct dark patch near the tip of the abdomen, which the wingless adults lack. On adults, the pair of rearward cornicles on the abdomen are markedly swollen or clublike at the tip.

The turnip aphid (also called mustard aphid) is a worldwide pest of cole crops. In California cole crop production, it is most commonly a problem in the low desert. These aphids are dark to olive green and have apparent cornicles, which are shorter than those of the green peach aphid. The waxy coating on the turnip aphid is also much thinner and less apparent than that of the cabbage aphid.

<table>
<thead>
<tr>
<th>Cabbage aphid</th>
<th>Green peach aphid</th>
<th>Turnip aphid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thick, waxy coating</td>
<td>No waxy coating</td>
<td>Thin, less apparent waxy coating</td>
</tr>
<tr>
<td>Dense colonies</td>
<td>More randomly dispersed on plants</td>
<td>More randomly dispersed on plants</td>
</tr>
</tbody>
</table>

**DAMAGE**
Green peach aphid can stunt seedling growth when abundant, and high numbers sometimes kill young seedlings or transplants. Economic damage is rare on older plants. Green peach aphids tend to feed on older leaves and rarely enter heads of broccoli, Brussels sprouts, cabbage, or cauliflower.

Turnip aphids feeding on cole crop roots can seriously stunt, and even kill, plants.

**MANAGEMENT**
In coastal cole crop-growing areas, both green peach and turnip aphids rarely require insecticide application. Because green peach aphids remain mostly on the older, nonmarketed leaves of cole crops, low to moderate numbers can be tolerated on older plants. Apply an insecticide to infested young plants if they show stress from feeding by green peach aphid.

In the low desert, infestations of both turnip aphid and green peach aphid often require insecticide application. Apply insecticide if green peach aphids or turnip aphids are numerous enough to contaminate the marketable heads. Time insecticide application to reduce aphid infestations before they reach the marketable heads. Turnip aphids typically require insecticide application between January and April.

**Biological Control**
Many general predators and parasitic wasps attack foliage-feeding aphids. Brown or black mummified bodies of aphids indicate the larvae of the parasitic wasps *Aphidius matricariae, Aphelinus semiflavus,*
Diaeretiella rapaeLysiphlebus testaceipes, or other parasites fed on the inside of the aphids and killed them. Sometimes natural enemies provide adequate biological control, especially in fields where residual, broad-spectrum insecticides are not applied. Consider installing insectary plants to attract natural enemies of aphids.

Cultural Control
Remove infested culls and weeds around fields that may harbor aphids that move to crops. Turnip aphid problems tend to recur in the same fields; long-term rotation to other crops (such as lettuce) is advised.

Organically Acceptable Methods
Use primarily biological and cultural controls in an organically certified crop. Sprays of insecticidal soap and other organic insecticides are also registered for aphid control in organic cole crops.

Monitoring and Treatment Decisions
Keep notes on the number of other aphids you see as you monitor for cabbage aphid. Apply insecticide to seedlings if they appear to be stressed by aphids based on monitoring information and observed damage. Older plants can tolerate low to moderate numbers of aphids. An application for cabbage aphid just before heading also controls the other foliar aphids.

<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>A. SPIROTETRAMAT (Movento)</td>
<td>4–5 fl oz</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. FLONICAMID (Beleaf 50 SG)</td>
<td>2–2.8 oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Thorough spray coverage is essential for optimal control.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. PYMETROZINE (Fulfill)</td>
<td>2.75 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 9B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Best used in a tank mix with another insecticide registered for aphids.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. ACETAMIPRID (Assail 70 WP)</td>
<td>See comments</td>
<td>12</td>
<td>See comments</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: For head and stem cole crops, application rate for aphids is 0.8 to 1.7 oz per acre and PHI is 7 days. For leafy cole crops, application rate for aphids is 0.8 to 2.3 oz per acre and PHI is 3 days. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. ACEPHATE (Orthene 97)</td>
<td>8–16 oz</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 1B</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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COMMENTS: Registered for use on Brussels sprouts and cauliflower only.

F. INSECTICIDAL SOAP
(M-Pede)#
1–2% solution 12 0
MODE-OF-ACTION: A contact insecticide with smothering and barrier effects.
COMMENTS: Provides only partial control. For green peach aphid, label requires that this product be used in a tank mix with a labeled companion insecticide. May be phytotoxic on Brussels sprouts and cabbage. Check with organic certifier to determine which products are organically acceptable.

Organic Options (Efficacy research may be lacking on these products)

A. AZADIRACHTIN
(AzaGuard)#
8 fl oz 4 0
MODE-OF-ACTION GROUP NUMBER#: un
COMMENTS: Not registered for use on mustard spinach. Rate included is based on tank mix efficacy research. May not significantly reduce aphids as a standalone application. Check with organic certifier to determine which products are organically acceptable.

AND...
BEAUVERIA BASSIANA STRAIN GHA
(Mycotrol ESO)#
0.25–1 qt 4 0
MODE-OF-ACTION GROUP NUMBER#: biological (entomopathogenic fungi)
COMMENTS: Not registered for use on broccoli, mizuna, and mustard spinach. More effective on aphid nymphs. When applied to soil, this fungus promotes cabbage growth by increasing nutrient absorption even when moisture is reduced. May not significantly reduce aphids as a standalone application. Check with organic certifier to determine which products are organically acceptable.

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# Acceptable for use on organically grown produce.
IMPORTED CABBAGEWORM (12/20)

Scientific Name: *Pieris rapae*

**DESCRIPTION OF THE PEST**

Larvae (caterpillars) are green with numerous fine hairs that give their skin a velvety appearance. Older larvae may be up to 1 inch long, and often have one faint yellow-orange stripe along their back and broken stripes along the sides. Compared to other caterpillars, cabbageworms move slowly and are sluggish. They feed voraciously on both the outer and inner leaves, often feeding along the midrib, at the base of the wrapper leaves, or boring into the heads of cabbage.

After feeding for about 2 to 3 weeks, larvae pupate attached to their host by a few silk strands. Pupae are green with faint yellow, lengthwise lines; there is no dense silk covering or cocoon.

The adult cabbage butterfly is white to pale yellowish with a wingspan of 1.5 inches and has one to four black spots on each forewing. Adults are often seen fluttering around fields and blossoming, low-growing plants. Adult females lay whitish, elongated eggs singly on the undersides of leaves. Eggs are pointed at the top and have pointed ridges down the sides.

The cabbageworm has several generations per year. It can be active throughout the year where hosts are present.

**DAMAGE**

Cabbageworm larvae chew seedlings and large, irregular holes in leaves, bore into heads, and may contaminate marketed produce with greenish-brown fecal pellets. Most economic damage is to the marketed plant parts.

**MANAGEMENT**

Closely watch seedlings, which quickly become damaged if the pest becomes abundant.

Between thinning or transplanting and heading, cole crops tolerate considerable damage from caterpillars eating leaves. During this time, sample frequently enough to assess numbers accurately and avoid unnecessary insecticide application that can disrupt biological control.

Once plants begin to head, even low numbers of imported cabbageworm can cause serious economic damage and may require insecticide application.

**Cultural Control**

To prevent imported cabbageworms from migrating into the crop, control cruciferous weeds (such as mustards) that can host them.

**Biological Control**

Important natural enemies include the pupal parasite *Pteromalus puparum*, the larval-parasitic wasps *Apanteles glomeratus* and *Microplitis plutellae*, several tachinid flies, and egg-parasitic *Trichogramma* species. Natural viral infections may also provide effective control.

Consider installing insectary plants to attract natural enemies. Avoid the use of broad-spectrum insecticides that disrupt the biological control of imported cabbageworm by natural enemies.
Organically Acceptable Methods

Use biological control, cultural control, and sprays of *Bacillus thuringiensis* and the Entrust SC formulation of spinosad in an organically certified crop.

Monitoring and Treatment Decisions

Combine monitoring of imported cabbageworm with monitoring for cabbage looper. Compared with cabbage looper, imported cabbageworm may be harder to find because its maximum size is smaller than other caterpillars and its green color is inconspicuous on plants.

On a weekly basis beginning at seedling emergence or right after transplanting, check 25 plants selected randomly throughout the field.

- Note the time when many adults (butterflies) are fluttering around the field. A few days later, check plants for eggs and small larvae on the underside of leaves.
- Look for larger caterpillars toward the center of the plant where they often feed near the midrib of leaves.
- Look for greenish-brown fecal pellets.

Base treatment on the combined number of healthy imported cabbageworm and cabbage looper larvae found.

- In the early stages of crop development, apply an insecticide if medium-sized to large caterpillars are numerous enough to stunt growth (approximately 1 caterpillar for every 5 plants).
- Prior to heading on well-established crops (except for Brussels sprouts), do not apply insecticide unless more than 9 caterpillars are found per plant.
  - For Brussels sprouts, apply insecticide just before heading or at Brussels sprouts formation if 1 or more caterpillars is found in 25 plants.
- From heading to harvest, apply insecticide if more than 10% of the sampled plants (2–3 plants out of 25) are infested with at least 1 caterpillar.

Where possible, use *Bacillus thuringiensis* to avoid harming natural enemies. *Bacillus thuringiensis* is very effective against imported cabbageworm and cabbage looper, especially when applied to early-instar (young) larvae. If significant numbers of beet armyworm, diamondback moth, or cutworms are also present, use a broad-spectrum insecticide recommended for these species to also control imported cabbageworm.

### Common name

<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><em>Bacillus thuringiensis</em> ssp. Kurstaki (Condor WP)#</td>
<td>0.5–2 lb</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>MODE-OF-ACTION GROUP NUMBER</strong>: 11A</td>
<td><strong>COMMENTS</strong>: Not registered for use on broccoflower (cavalo), mizuna, and mustard spinach. Check with organic certifier to determine which products are organically acceptable. Label strongly recommends an approved spreader-sticker for application in cole crops.</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.*

*Imported Cabbageworm (12/20) 42*

Illustrated version at [http://ipm.ucanr.edu/agriculture/cole-crops/](http://ipm.ucanr.edu/agriculture/cole-crops/)
B.  **CHLORANTRANILIPROLE**  
(Coragen)  
3.7–7.5 fl oz  
4  
MODE-OF-ACTION GROUP NUMBER: 28  
COMMENTS: Foliar application; use with an effective adjuvant for best performance. Use higher application rates within this range for heavier infestations, larger or denser crops, or extreme environmental conditions such as rainy weather or high temperatures.

C.  **SPINETORAM**  
(Radiant SC)  
5–10 fl oz  
4  
MODE-OF-ACTION GROUP NUMBER: 5  
COMMENTS: Toxic against some natural enemies (predatory beetles, syrphid fly larvae, and predatory thrips) when sprayed and 5 to 7 days after. Control improved with addition of an adjuvant.

D.  **SPINOSAD**  
(Entrust SC)  
3–6 fl oz  
4  
(Success)  
3–6 fl oz  
4  
MODE-OF-ACTION GROUP NUMBER: 5  
COMMENTS: Toxic against some natural enemies (predatory beetles, syrphid fly larvae, and predatory thrips) when sprayed and 5 to 7 days after. Must be applied when eggs are present or larvae are small. For organic formulations, check with organic certifier to determine which products are organically acceptable.

E.  ** METHOXYFENOZIDE**  
(Intrepid 2F)  
See comments  
4  
MODE-OF-ACTION GROUP NUMBER: 18  
COMMENTS: Use a rate of 4–8 fl oz per acre for early-season applications to young crops. Use a rate of 8–10 fl oz per acre for mid- to late-season infestations and heavier infestations.

F.  **EMAMECTIN BENZOATE**  
(Proclaim)  
2.4–4.8 oz  
12  
MODE-OF-ACTION GROUP NUMBER: 6  
COMMENTS: PHI is 7 days for head and stem cole crops and 14 days for leafy cole crops.

G.  **INDOXACARB**  
(Avaunt)  
2.5–3.5 oz  
12  
MODE-OF-ACTION GROUP NUMBER: 22  
COMMENTS: Add a wetting agent to improve coverage. Minimum interval between sprays is 3 days.

H.  **CRYOLITE**  
(Prokil Cryolite 96)  
8–16 lb  
12  
MODE-OF-ACTION GROUP NUMBER: 8C  
COMMENTS: For use on broccoli, Brussels sprouts, cabbage, and cauliflower. Use on cabbage is allowed based on a supplemental label (EPA Reg. No. 10163-41). For broccoli, Brussels sprouts, and cauliflower, preharvest interval is 7 days. For cabbage, preharvest interval is 14 days. Must be ingested by the insect. Apply when early instars are present. Can be useful in an insecticide resistance-management program.

‡ 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 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 are assigned by IRAC (Insecticide Resistance Action Committee).
# Acceptable for use on organically grown produce.
* Permit required from county agricultural commissioner for purchase or use.
LEAFMINERS (12/20)

Scientific Name: *Liriomyza* spp.

DESCRIPTION OF THE PEST
Adults are small, black flies. They are about 0.06 inch (1.5 mm) long, with a bright yellow triangle on the thorax between the base of the wings and yellow on the face and underside. Eggs are laid in the leaf tissue and hatch in 2 to 4 days during warm weather.

The yellow maggots (larvae) of leafminers grow to be up to 0.1 inch (2.5 mm) long as they feed between the upper and lower surface of leaves. Feeding by the maggots causes distinctive winding, whitish tunnels that increase in length and width as the larva grows. Mature maggots emerge to pupate on the leaf surface or in or on soil.

Leafminers have many generations per year. One generation can be completed in less than 3 weeks during warm weather.

DAMAGE
Females puncture leaves to feed on plant sap. When high numbers of females lay eggs in leaf tissue, numerous pale spots will be present on leaves. Leafminer feeding can reduce the plant’s photosynthetic capacity, render edible leaf portions unmarketable, and provide entrance sites for plant pathogens.

MANAGEMENT
Leafminers are primarily seedling pests. Regularly monitor seedlings and young plants to determine if an insecticide application is necessary.

Cultural Control
Where possible, avoid planting next to infested fields, especially when such fields are near time to harvest. Leafminers attack a wide variety of vegetable crops, and readily migrate to cole crops from nearby hosts. Cultivate or destroy infested weeds and crop residue after harvest.

Biological Control
Natural enemies, especially *Chrysocharis* and *Diglyphus* spp. parasitic wasps, commonly control leafminers. Choose selective pesticides when managing other seedling pests to avoid disrupting leafminer biological control. Consider installing insectary plants to attract natural enemies of leafminers.

Organically Acceptable Methods
Use cultural controls and the Entrust SC formulation of spinosad in an organically certified crop.

Monitoring and Treatment Decisions
Regularly check young seedlings and transplants for leaf mines. Most mines occur on the cotyledons and first true leaves. If leafminers are numerous when seedlings have five or fewer true leaves, an insecticide application may be necessary. Apply an insecticide if there are an average of one or more mines per leaf in the overall field samples in the early stages of crop growth.

While leafminer infestations at early stages of growth can be detrimental to yields, broccoli and cauliflower with six or more leaves are rarely damaged by leafminers, regardless of their numbers.
Parasitic wasps usually keep leafminers below damaging numbers as long as disruptive pesticides (such as pyrethroids) are not applied.

For cabbage, consider applying insecticide if edible leaves are mined.

<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>A. SPINETORAM (Radiant SC)</td>
<td>6–10 fl oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Toxic against some natural enemies (predatory beetles, syrphid fly larvae, and predatory thrips) when sprayed and 5 to 7 days after. Control improved with addition of an adjuvant.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. SPINOSAD (Entrust SC)#</td>
<td>4–10 fl oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Toxic against some natural enemies (predatory beetles, syrphid fly larvae, and predatory thrips) when sprayed and 5 to 7 days after. Use higher rate for heavy infestations.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. CYROMAZINE (Trigard)</td>
<td>2.66 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 17</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.

‡ 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 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 are assigned by IRAC (Insecticide Resistance Action Committee).

# Acceptable for use on organically grown produce
LEAFROLLERS (12/20)

Scientific Names:  
- Garden tortrix: *Clepsis peritana*  
- Light brown apple moth: *Epiphyas postvittana*  
- Orange tortrix: *Argyrotaenia franciscana* (=*A. citrana*)

DESCRIPTION OF THE PEST

The garden tortrix, light brown apple moth, and orange tortrix are leafroller pests of cole crops in coastal areas.

Adults (moths) of these leafrollers have:
- light brown bodies with brown markings
- wings that form a bell shape while at rest
- protruding mouthparts that resemble a snout

<table>
<thead>
<tr>
<th>Life stage</th>
<th>Garden tortrix</th>
<th>Light brown apple moth</th>
<th>Orange tortrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>adult</td>
<td>0.25 inch</td>
<td>0.25–0.5 inch</td>
<td>0.5 inch</td>
</tr>
<tr>
<td>larva (full grown)</td>
<td>0.5 inch</td>
<td>0.5–0.75 inch</td>
<td>0.5 inch</td>
</tr>
</tbody>
</table>

Females lay masses of 20 to 170 eggs on smooth surfaces, such as shoots or the upper surface of leaves. The elliptical eggs are laid overlapping each other, resembling fish scales, and can be difficult to find. Eggs are often light green initially, then greenish-brown as the embryos develop.

When disturbed, leafroller caterpillars wriggle vigorously, drop from plants suspended by a silken thread, or both. Larvae and pupae overwinter in debris around the base of the plant.

Leafrollers are not well studied on cole crops. They may have one to four generations per year, depending on species and location.

**Garden Tortrix**

The adult garden tortrix has a dark brown marginal spot on each forewing. Anterior to the spot is a dark brown, diagonal stripe that forms a chevron (V shape) pattern when at rest and has a faint whitish line bordering the front edge. The darker markings and otherwise lighter color of the forewings distinguish adult garden tortrix from orange tortrix.

Garden tortrix larvae are slender, with light brown to green bodies. The light brown head has a small, distinct, dark brown spot on each side. There is a darker area (prothoracic shield) on top of the first segment behind the head.

**Orange Tortrix**

At rest, the orange tortrix female moth generally has a faint, brown, V-shaped mark where the forewings meet. The male has a darker, wider chevron mark. Compared to the dark brown chevron on garden tortrix, the V marking on orange tortrix is a lighter color and less distinct.

Larvae are 0.2 inch (5 mm) long just after hatching and grow to 0.5 inch, about twice the length of the mature garden tortrix. Older orange tortrix larvae have greenish to straw-colored bodies with a yellowish
Leafroller or straw-colored head and prothoracic shield. Larvae commonly feed singly on shoot tips and succulent leaves they web together with silk.

Larvae pupate in a silk cocoon in webbed foliage. Adults emerge about 1 to 3 weeks after pupation, depending on temperature. Orange tortrix has two to four generations per year, and all stages can be present throughout the year.

**Light Brown Apple Moth**
(View the Field Identification Guide)

Light brown apple moth (LBAM) was previously classified as a federally quarantined invasive pest. However, the federal quarantine was lifted in December 2021, since the damage caused by this pest was less than expected.

The exotic light brown apple moth (LBAM) is found in coastal California from Los Angeles to Sonoma counties. In its native range (Australia), it does not survive well in hot, dry conditions. Because of its low tolerance to these conditions, it is less likely to be a problem in the San Joaquin Valley and southern desert, where these conditions occur seasonally.

Older larvae are pale to medium green with a light brown to yellowish head. The first segment behind the head (prothoracic shield) is greenish with no dark markings. However, the larvae cannot be reliably distinguished from other tortricids based on appearance.

Adults (moths) resemble many other tortricids, but light brown apple moth’s wing coloration varies more greatly, ranging from mostly light brown to contrasting light and dark brown (two-toned), especially in males. Unlike garden tortrix and orange tortrix, male light brown apple moths have an extension on the outer edge of the forewing called a costal fold. Females lack the costal fold.

Moths emerge 1 to 3 weeks after pupation. They stay sheltered in foliage during the day, resting on the underside of leaves. Females begin to lay eggs at night on the upper side of leaves 2 to 3 days after emerging. Larvae overwinter as second to fourth instars on weeds or other vegetation and may survive during winter without feeding for up to 2 months. Depending on location, light brown apple moth may have two to four generations per year.

**DAMAGE**

Leafroller feeding on marketed parts of cole crops or the florets is generally minor, so direct damage from leafrollers is rarely economically significant.

Leafroller larvae commonly tie one or more leaves together with silk and chew the foliage within these webbed shelters. Cole crops near native and riparian vegetation or urban landscapes may be more likely to attract leafrollers. Each leafroller species feeds on many species of plants, and adults can migrate from alternative hosts to lay their eggs on cole crops.

**MANAGEMENT**

**Biological Control**

General insect predators and several species of spiders can reduce leafroller numbers by feeding on eggs or larvae. Larvae of several species of parasitic tachinid flies and wasps are especially effective natural enemies of leafroller larvae and pupae if broad-spectrum, persistent insecticides are not applied.
Cultural Control
Early weed control and prompt destruction of infested crop residue can reduce leafroller numbers. However, moths can fly for several miles and cause new infestations.

Organically Acceptable Methods
Use biological and cultural control, as well as applications of *Bacillus thuringiensis* spp. *kurstaki* and the Entrust SC formulation of spinosad in an organically certified crop. When using *B. thuringiensis*, apply multiple times and at close intervals. When mixing, decrease the water volume to concentrate the dose ingested by the larvae, but make sure the volume applied still ensures thorough spray coverage. Targeting a specific larval stage is difficult because leafrollers have overlapping generations.

Monitoring and Treatment Decisions
Use good sanitation to prevent infestations and monitor for leafrollers while monitoring for other caterpillars. Since the light brown apple moth quarantine has been lifted, insecticide applications for leafrollers in cole crops are rarely needed.

During the growing season through harvest:
1. Examine plants for frass (excrement consisting of black dots that look similar to poppy seeds), larvae, rolled leaves, and webbing, mainly under lower leaves and in the mid-canopy. Rolled leaves, one or more leaves webbed together, and webbing made by larvae are generally not difficult to locate.
2. Where leafroller activity is detected, search on nearby plants for more. Infestations are typically clustered.
3. When larvae are detected on leaves close to florets during harvest, separate those plants from the marketable produce and destroy them.

Insecticide sprays for other lepidopteran pests such as beet armyworm and diamondback moth may also control leafrollers.

<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>A. SPINOSAD (Entrust SC)#</td>
<td>8 fl oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>SUCCESS (Success)</td>
<td>8 fl oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Most effective against younger larvae. Rotate to an insecticide with a different mode of action after two successive applications. Maintaining proper pH of the spray-tank water is critical for maximum efficacy. Check with organic certifier to determine which products are organically acceptable.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. SPINETORAM (Radiant SC)</td>
<td>5–10 fl oz</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 5</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.
<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>COMMENTS:</strong> It is extremely important to rotate to an insecticide with a different mode of action after two successive applications. Because they have the same mode of action, resistance has developed where rotations have been made between spinosad and spinetoram. Maintaining proper pH of the spray-tank water is critical for maximum efficacy.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. **BACILLUS THURINGIENSIS** ssp. **KURSTAKI**  
(Condor WP)#  
MODE-OF-ACTION GROUP NUMBER: 11A  
COMMENTS: Not registered for use on broccoflower (cavalo), mizuna, and mustard spinach. To be effective, must be applied no later than the second instar. Check with organic certifier to determine which products are organically acceptable. Label strongly recommends an approved spreader-sticker for application in cole crops.  

D. **CHLORANTRANILIPROLE**  
(Coragen)  
MODE-OF-ACTION GROUP NUMBER: 28  
COMMENTS: Use higher application rates within this range for heavier infestations, larger or denser crops, or extreme environmental conditions such as rainy weather or high temperatures.  

E. **METHOXYFENOXIDE**  
(Intrepid 2F)  
MODE-OF-ACTION GROUP NUMBER: 18  
COMMENTS: For head and stem cole crops, PHI is 7 days. For leafy cole crops, PHI is 14 days.  

F. **EMAMECTIN BENZOATE**  
(Proclaim)  
MODE-OF-ACTION GROUP NUMBER: 6  
COMMENTS: For head and stem cole crops, PHI is 7 days. For leafy cole crops, PHI is 14 days.  

G. **METHOMYL***  
(Lannate SP)  
MODE-OF-ACTION GROUP NUMBER: 1A  
COMMENTS: Registered for use on broccoli, Brussels sprouts, cabbage, Chinese cabbage, cauliflower, collards, kale, and mustard greens. Also available for use on broccoli raab and Chinese broccoli through Special Local Needs labels (broccoli raab: EPA SLN No. CA-900034, Chinese broccoli: EPA SLN No. CA-860059).  

H. **INDOXACARB**  
(Avaunt)  
MODE-OF-ACTION GROUP NUMBER: 22A

\[‡\] 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.  

\[\text{†} \] 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 are assigned by IRAC (Insecticide Resistance Action Committee).  

\[\# \] Acceptable for use on organically grown produce.  

\[* \] Permit required from county agricultural commissioner for purchase or use.
Lygus Bug (Western Tarnished Plant Bug) *(12/20)*

**Scientific Name:** *Lygus hesperus*

**DESCRIPTION OF THE PEST**

Lygus bug is also known as western tarnished plant bug. Adults are true bugs about 0.25 inch long and are variably colored yellowish to green or bronze. Adults have a distinctive triangular marking on the back, and their wings consist of both membranous and hardened sections that are folded over the back. The mouthparts of these bugs are needlelike and long compared to the overall size of their bodies.

Females lay eggs in the plant tissue, typically in the midrib areas of leaves. Nymphs are light green and are shaped similar to adults, but lack wings. First instar nymphs can be confused with aphids when casually observed, but lack cornicles and move much faster than aphids. Second and third instars have a dark spot on the abdomen, and fourth and fifth instars have four additional spots on their thoracic segments. In general, later instars can be recognized by their developing wing pads.

**DAMAGE**

Lygus feeds by piercing plant tissues. This activity damages the plant tissue and deforms the developing leaves. Egg laying also causes lesions to develop. These injuries initially appear as holes or pits on stems and leaves and sometimes develop into lesions.

**MANAGEMENT**

**Biological Control**

Though various natural enemies attack different life stages of the lygus bug, natural enemies are unlikely to be present in fields in sufficient numbers to control lygus bugs before they damage cole crops (which typically occurs at the young seedling or transplant stage). Natural infections with entomopathogenic fungi can sometimes kill lygus bugs, but such infections usually do not provide substantial control.

**Cultural Control**

Manage weeds around the fields to suppress lygus bug numbers. Controlling weeds along roadways, ditches, and field borders near cole crop fields to help prevent spring buildup of lygus bugs is fundamental to lygus management.

**Organically Acceptable Methods**

Use biological control, cultural controls, and organically approved insecticides to manage lygus bugs on organically certified crop.

**Monitoring and Treatment Decisions**

Lygus bug adults can move into and damage the crop at any stage of growth, but young plants are particularly susceptible to feeding injury. Thus, it is essential to scout for the movement of adult lygus bugs into the field during the early stages of crop growth.

Lygus bugs frequently move into crop fields in spring, when weeds and native vegetation dry up. Determining the level of lygus bug infestation is difficult because the insects are cryptic (hiding), and their activity cycle during any day varies greatly. Lygus bugs become inactive and hard to find during temperature extremes and windy conditions.
To detect lygus bugs:
- Use sweep net sampling on the weed hosts
- Watch for adults flying out of the crop when walking through the field.

These are the only ways to check for the presence of lygus bug. Sticky traps are not useful for monitoring this pest.

Confirm the presence of lygus bugs before making pesticide application decisions. No thresholds have been established.

<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. **FLONICAMID**
   (Beleaf 50 SG)
   MODE-OF-ACTION GROUP NUMBER: 29
   COMMENTS: Thorough coverage is necessary for optimal control.
   2.0–2.8 oz 12 0

B. **NOVALURON**
   (Rimon 0.83EC)
   MODE-OF-ACTION GROUP NUMBER: 15
   COMMENTS: Registered for use in broccoli, Chinese broccoli, Brussels sprouts, broccoflower, cabbage, Chinese cabbage, cauliflower, Chinese mustard, and kohlrabi.
   12 fl oz 12 7

C. **FLUPYRADIFURONE**
   (Sivanto 200 SL)
   MODE-OF-ACTION GROUP NUMBER: 4D
   7–14 fl oz 12 1

D. **FENPROPATHRIN**
   (Danitol 2.4 EC)
   MODE-OF-ACTION GROUP NUMBER: 3A
   COMMENTS: Registered for use in broccoli, Chinese broccoli, Brussels sprouts, broccoflower, cabbage, Chinese cabbage, cauliflower, Chinese mustard, and kohlrabi.
   10.66–16 fl oz 24 7

E. **BIFENTHRIN**
   (Brigade 2EC)
   MODE-OF-ACTION GROUP NUMBER: 3A
   5.12–6.4 fl oz 12 7

F. **ACETAMIPRID**
   (Assail 70WP)
   MODE-OF-ACTION GROUP NUMBER: 4A
   COMMENTS: Controls nymphs better than adults. For head and stem cole crops, application rate is 0.8 to 1.7 oz and PHI is 7 days. For leafy cole crops, application rate is 0.8 to 2.3 oz and PHI is 3 days.
   See comments 12 See comments

G. **THIAMETHOXAM/CHLORANTRANILIPROLE**
   (Durivo)
   MODE-OF-ACTION GROUP NUMBER: 4A/28
   10–13 fl oz 12 30
COMMENTS: Thiamethoxam and its metabolites (which include the neonicotinoid clothianidin) are highly toxic to bees; may pose a risk to pollinators in crops grown for seed. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

H. THIAMETHOXAM
(Platinum)
5–11 fl oz 12 30
MODE-OF-ACTION GROUP NUMBER1: 4A
COMMENTS: Controls nymphs better than adults. Not registered for use on crops grown for seed. Thiamethoxam and its metabolites (which include the neonicotinoid clothianidin) are highly toxic to bees. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

I. PERMETHRIN
(Perm-Up 25DF)
Label rates 12 1
MODE-OF-ACTION GROUP NUMBER1: 3A
COMMENTS: Registered for use in broccoli, Brussels sprouts, cabbage, certain types of Chinese cabbage (see label) cauliflower, and collards. Do not use if leafminers are present.

J. METHOMYL*
(Lannate LV)
Label rates 48 See label
MODE-OF-ACTION GROUP NUMBER1: 1A
COMMENTS: Not registered for use on broccoflower (cavalo), kohlrabi, mizuna, mustard spinach, or rape greens. This active ingredient is very disruptive to natural enemies. If both caterpillars and western tarnished plant bug must be controlled, it can be used; otherwise use a different insecticide. Application rates are crop-specific. Add a wetting agent to improve coverage.

K. ZETA-CYPERMETHRIN
(Mustang)
3.4–4.3 fl oz 12 1
MODE-OF-ACTION GROUP NUMBER1: 3A
COMMENTS: Do not use if leafminers are present. In certain cole crops exported to Canada (broccoli, Brussels sprouts, cabbage, and cauliflower), PHI of 14 days is recommended in order to meet tolerances—see FIFRA 2(ee) recommendation for more information.

Organic Options (Efficacy research may be lacking on these products)

A. BEAVARIA BASSIANA STRAIN GHA
(Mycotrol ESO)#
0.25–1 qt 4 0
MODE-OF-ACTION GROUP NUMBER1: biological
COMMENTS: Not registered for use on broccoflower, mustard spinach, and mizuna. In Canada, bees are often used to deliver the product to plants; nevertheless, it is potentially pathogenic to bees and most other insects. When applied to the soil, increases the growth and health of cabbage plants even when moisture is reduced. Check with your organic certifier to determine which B. bassiana products are organically acceptable.

AND...

AZADIRACHTIN
(AzaGuard)#
8 fl oz 4 0
MODE-OF-ACTION GROUP NUMBER1: un
COMMENTS: Not registered for use on mustard spinach. Alternative to novaluron in organic cole crop production. Check with organic certifier to determine which azadirachtin products are organically acceptable.

B. AZADIRACHTIN
(AzaGuard)#
16 fl oz 4 0
MODE-OF-ACTION GROUP NUMBER1: un
COMMENTS: Not registered for use on mustard spinach. Alternative to novaluron in organic cole crop production. Check with organic certifier to determine which azadirachtin products are organically acceptable. High rate of
azadirachtin is effective against lygus bug as a standalone application; low rate may not significantly reduce lygus bugs as a standalone application.

† 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 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 are assigned by IRAC (Insecticide Resistance Action Committee).

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

‡ Acceptable for organically grown produce.
SEEDCORN MAGGOT (12/20)

Scientific Name: *Delia platura*

DESCRIPTION OF THE PEST
Seedcorn maggot larvae are legless, white, and up to 0.4 inch long. They cannot be distinguished from other *Delia* spp., such as cabbage maggot, without microscopic examination by a taxonomist. However, unlike cabbage maggot, seedcorn maggot does not attack plants after the seedling stage and is rarely found tunneling in larger roots. Their damage is typically restricted to cole crops that are 1 to 2 weeks old.

Adults are dark gray flies about one-half the size of the common house fly. Females are attracted to lay eggs in moist soil that is high in organic matter. Larvae burrow beneath the surface to feed for 1 to 3 weeks on seeds and germinating seedlings. Mature larvae form oblong, brown pupae in soil.

Seedcorn maggot can be a problem in coastal areas on broccoli and cauliflower if the weather is cool and wet. There are several generations per year. Seedcorn maggots are most prevalent during cool spring conditions, especially after wet winters. Their numbers may decline in summer.

DAMAGE
The larvae damage and kill germinating seeds and very small seedlings. Affected seedlings may wilt, be abnormally light green, and stunted. Once the stand is established and seedlings have developed a few leaves, seedcorn maggot is unlikely to cause economic damage.

MANAGEMENT
The key to reducing damage from seedcorn maggot is allowing plant debris and other organic matter to completely decompose before planting. Once crop seedlings emerge or right after transplanting, watch for wilting, atypically light-green plants, or reduced growth, which may indicate a seedcorn maggot infestation.

Use primarily cultural controls to manage seedcorn maggot:
- Disc under cover crops at least 2 weeks before planting.
- Allow crop residue to completely decompose before planting cole crops.
- When direct seeding, attach drag chains behind the planter to eliminate the moisture gradient from overturned soil that may attract egg-laying females to the seed row.
- Transplant instead of direct seeding.
- Insecticides are generally not necessary in desert areas where seedcorn maggot is not a problem. Cole crops typically grow out of seedcorn maggot damage in this region.

In areas where seedcorn maggot damage is a problem, seed treatment or a soil-applied insecticide are effective forms of control.

In the San Joaquin Valley, spring-planted fields with soil high in organic matter may require insecticide application. However, to avoid damage from seedcorn maggot, it is best to plant only after organic matter has decomposed.

<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>

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Seedcorn Maggot (12/20) 55
Illustrated version at http://ipm.ucanr.edu/agriculture/cole-crops/
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**

A. **CLOTHIANIDIN**  
   (NipsIt Vegetables)  
   Label rates  
   12 NA  
   **MODE-OF-ACTION GROUP NUMBER**: 4A  
   **COMMENTS**: Registered for use on only broccoli seeds in California, but seed treated in and obtained from another state can be legally used in California even if the chemical is not registered on the crop in California. Contact your retail seed dealer for information and availability. Application rate per seed depends on the amount of seed planted per acre.

**Soil Application**

A. **CLOTHIANIDIN**  
   (Belay)  
   9–12 fl oz  
   12 21  
   **MODE-OF-ACTION GROUP NUMBER**: 4A  
   **COMMENTS**: Soil application. Highly toxic to bees for more than 5 days after an application. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

B. **BIFENTHRIN**  
   (Capture LFR)  
   3.4–6.8 fl oz  
   12 NA  
   **MODE-OF-ACTION GROUP NUMBER**: 3A  
   **COMMENTS**: Preplant or at-plant application.

C. **CHLORANTRANILIPROLE/THIAMETHOXAM**  
   (Durivo)  
   10–13 fl oz  
   12 30  
   **MODE-OF-ACTION GROUP NUMBER**: 28/4A  
   **COMMENTS**: Thiamethoxam and its metabolites (which include the neonicotinoid clothianidin) are highly toxic to bees; may pose a risk to pollinators in crops grown for seed. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

D. **CYANTRANILIPROLE**  
   (Verimark)  
   10–13.5 fl oz  
   4 NA  
   **MODE-OF-ACTION GROUP NUMBER**: 28  
   **COMMENTS**: Allowed for at-plant application only (see label for more information).

E. **DIAZINON**  
   (Diazinon 50W)  
   4–6 lb  
   96 (4 days) NA  
   **MODE-OF-ACTION GROUP NUMBER**: 1B  
   **COMMENTS**: Preplant or transplant water application only (see label for more information). Not registered for use on kohlrabi, mizuna, mustard spinach, and rape greens. Avoid drift and tailwater runoff into surface waters.

† 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.

\[1\] 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 are assigned by IRAC (Insecticide Resistance Action Committee).
SPRINGTAILS (12/20)
Scientific Names: Prophorura fimata

DESCRIPTION OF THE PEST
Springtails are minute, primitive, insectlike organisms. Their bodies are less than 0.1 inch (2.5 mm) long and wingless. Most springtails are harmless scavengers, and are considered beneficial organisms because they aid in the decomposition of decaying plant material. However, P. fimata has been found to cause problems in cole crops in the Salinas Valley.

Most springtails have a forked appendage (furcula) at the tip of the abdomen, which they use to spring into the air when disturbed. P. fimata lacks a furcula and curls up when disturbed instead of jumping. It also lacks pigmentation and eyes.

Springtails lay their round eggs in small groups in moist soil, especially where organic matter is abundant. The immature stage is usually whitish, and adults tend to be whitish, bluish, or lack pigmentation. The immature stage differs from the adult stage only in size and color.

DAMAGE
Springtail damage to cole crops is currently a problem in various parts of the Salinas Valley and the Central Coast. They are often a problem in fields that contain a high amount of organic matter and fields that have a recent history of their presence, though their infestations do not always occur under these conditions. Damage more often occurs in the spring than during other seasons. Springtails will stunt seedling growth by damaging germinating seeds, roots and seedling leaves when present in large numbers. The seedlings may appear wilted and may die if damaged when young. Damage occurs as minute, rounded pits on young, developing leaves or roots, or as irregular holes in thin leaves. Mature plants are typically not significantly injured.

MANAGEMENT
Recent additions of organic matter (such as adding compost or incorporating a cover crop as green manure) as well as intensive irrigation (high soil moisture level for seed germination) can temporarily and dramatically increase springtail numbers.

P. fimata can be mostly suppressed with early applications of synthetic insecticides directed at the seed line. An at-plant application of a pyrethroid, neonicotinoid, or spinosyn insecticide is often effective for both direct-seeded and transplanted cole crops. Seeds coated with a neonicotinoid insecticide targeted to manage other soilborne arthropod pests can also reduce springtail numbers.

Monitoring and Treatment Decisions
Monitoring is the key to determining the presence of springtails. There is currently no action threshold for springtails, but potato or beet slices can be used to monitor P. fimata presence or absence in the field. Determining whether or not springtails are present reduces unnecessary insecticide applications.

1. Cut thin slices (about 0.5 inch) of beet root or potato (preferably of a darker color).
2. Place the slices in the subsurface of the soil about 2 inches deep, and cover them with a plastic cover, such as white plastic bowls that are 3.5 inches in diameter and at least 1.5 inch deep.
3. Assess the slices about 24 hours after deployment. (Slices tend to dry out when left in the
field for longer periods of time, and thus become less attractive to $P. \textit{fimata}$.

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

**Seed Treatment**

A. CLOTHIANIDIN (NipsIt Vegetables)  
   MODE-OF-ACTION GROUP NUMBER: 4A  
   COMMENTS: Registered for use on only broccoli seeds in California, but seed treated in and obtained from another state can be legally used in California even if the chemical is not registered on the crop in California. Contact your retail seed dealer for information and availability. Application rate per seed depends on the amount of seed planted per acre.  
   Label rates  
   12  
   NA

B. SPINETORAM (Radiant SC)  
   MODE-OF-ACTION GROUP NUMBER: 5  
   5–10 fl oz  
   4  
   1

C. DINOTEFURAN (Venom)  
   MODE-OF-ACTION GROUP NUMBER: 4A  
   COMMENTS: Not registered for use on cole crops grown for seed. Rate above is for soil application. Registered for use on broccoli, broccoflower, Brussels sprouts, cabbage, cauliflower, Chinese cabbage, and kohlrabi. Highly toxic to bees for more than 38 hours after application. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.  
   5 oz  
   12  
   21

D. THIAMETHOXAM (Platinum)  
   MODE-OF-ACTION GROUP NUMBER: 4A  
   COMMENTS: Not registered for use on crops grown for seed. Thiamethoxam and its metabolites (which include the neonicotinoid clothianidin) are highly toxic to bees. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.  
   5–11 fl oz  
   12  
   30

E. CLOTHIANIDIN (Belay)  
   MODE-OF-ACTION GROUP NUMBER: 4A  
   COMMENTS: Rate and PHI above are for soil application. Highly toxic to bees for more than 5 days after an application. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.  
   9–12 fl oz  
   12  
   21

F. ZETA-CYPERMETHRIN (Mustang)  
   MODE-OF-ACTION GROUP NUMBER: 3A  
   COMMENTS: In certain cole crops exported to Canada (broccoli, Brussels sprouts, cabbage, and cauliflower), PHI of 14 days is recommended in order to meet tolerances — see FIFRA 2(ee) recommendation for more information.  
   2.4–4.3 fl oz  
   12  
   1

F. LAMBDA-CYHALOTHIRIN
<table>
<thead>
<tr>
<th>Common name (Example trade names)</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Warrior II with Zeon Technology)</td>
<td>1.6 fl oz</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Registered for use on head and stem cole crops only (see label for more information).</td>
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</tr>
</tbody>
</table>

G. PYRETHRINS
(PyGanic Crop Protection EC 1.4 II)\#
(MODE-OF-ACTION GROUP NUMBER‡: 3A)
(COMMENTS: Alternative to synthetic pyrethroids in organically grown cole crops. Check with organic certifier to determine which products are organically acceptable.

‡ 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.

† 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 are assigned by IRAC (Insecticide Resistance Action Committee).

# Acceptable for use on organically grown produce.
SWEETPOTATO WHITEFLY (12/20)

Scientific Name: *Bemisia tabaci* MEAM1

DESCRIPTION OF THE PEST
Several species of whiteflies may infest cole crops. Only the sweetpotato whitefly MEAM1, sometimes called silverleaf whitefly, causes economic damage. Proper identification of sweetpotato whitefly is important, because greenhouse whitefly (*Trialeurodes vaporariorum*) and other whiteflies do not require management in cole crops.

Whiteflies are found mostly on the undersides of leaves. An adult whitefly is 0.06 inch (1.5 mm) long, with a yellow abdomen and thorax, and white wings. Adults fly readily when plants are disturbed.

The tiny, oval eggs of sweetpotato whitefly hatch into translucent, mobile first instars (crawlers) that have short legs and antennae. After the first molt, nymphs lack antennae and legs, and remain fixed to the leaf surface. Older nymphs are oval and translucent, whitish, or yellowish. The last-instar nymph, also called a pupa or red-eye nymph, is the life stage most helpful for distinguishing the species.

Use a hand lens to identify both adults and nymphs of the sweetpotato whitefly:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Sweetpotato whitefly</th>
<th>Greenhouse whitefly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wings (at rest)</td>
<td>Rooflike, tilted</td>
<td>Flat, no tilt</td>
</tr>
<tr>
<td>Wings meet along the back and entirely cover the abdomen at rest</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Sweetpotato whitefly nymphs and pupae have no filaments projecting from the edge of the body, and few or no short filaments on top. In contrast, young greenhouse whitefly nymphs have a fringe of short filaments around their perimeter, and the last-instar nymphs (pupae) have several long, projecting, waxy filaments protruding from their bodies.

DAMAGE
Whiteflies damage cole crops by sucking plant sap and excreting copious honeydew that contaminates plant surfaces. Black sooty mold grows on the honeydew, which reduces photosynthesis. Sweetpotato whitefly feeding and excretions slow plant growth and development when they are numerous, which may delay harvest. Sweetpotato whitefly feeding on broccoli also causes bleaching of stems and leaf petioles, called broccoli white stem.

MANAGEMENT
Sweetpotato whitefly is a major problem in California’s southern desert and the southern San Joaquin Valley. It is only a sporadic pest in the Central Coast region. Natural enemies can help to control whiteflies, and cultural practices are important in helping to prevent severe infestation. Monitor for sweetpotato whitefly and apply insecticides when warranted. If whiteflies are migrating into the crop, applying insecticide only to field borders may be adequate.

Biological Control
Sweetpotato whitefly is an invasive pest, and no native natural enemies in California currently provide sufficient control. Numerous parasites and predators do attack it, but generally do not keep it below
damaging numbers. These natural enemies include parasitic wasps in the *Encarsia* and *Eretmocerus* genera, and predators of whitefly nymphs, such as bigeyed bugs, lacewing larvae, and lady beetles.

Some pathogens also attack sweetpotato whitefly, though naturally occurring infections do not typically provide sufficient control. Pathogens include the entomopathogenic fungi *Beauveria bassiana*, *Isaria fumosorosea* (*Cordyceps fumosorosea*) and *Verticillium lecanii*.

**Cultural Control**

Use the following cultural methods to control or suppress whitefly problems:

- In regions where sweetpotato whitefly is a regular problem, delay planting or use a host-free period to decrease the severity of whitefly infestation.
  - Numbers peak in late summer and begin to decrease by November. Delaying planting until November can greatly reduce sweetpotato whitefly infestations.
- When possible, plant cole crops at least one-half mile upwind from other key whitefly hosts, such as cotton and melons.
- Maintain good sanitation in winter and spring by removing weeds and other alternate hosts.
- Attempt to produce the crop in the shortest possible time to limit the extent to which whitefly numbers can increase in the crop; proper management of irrigation and nitrogen will assist in this.
  - See the UC ANR production guide for your specific crop for more details.
- Remove and destroy all crop residue and weed hosts of whiteflies as soon as possible (within 5 days) after harvest.

**Organically Acceptable Methods**

Use biological and cultural controls, as well as sprays of azadirachtin, entomopathogenic fungi, insecticidal soap and narrow-range oils, in an organically certified crop. The entomopathogenic fungi *Beauveria bassiana* and *Isaria fumosorosea* (*Cordyceps fumosorosea*) are commercially available for whitefly control. These products are most effective when used to control nymphs, and when used in combination with other insecticides. Fungicide application can reduce their efficacy.

Insecticidal soaps and oils are not as effective as other insecticides and require frequent applications and excellent coverage.

**Monitoring and Treatment Decisions**

In areas where sweetpotato whitefly is a problem (San Joaquin Valley and low desert), monitor for whiteflies as follows (note that these periods may vary slightly from year to year):

- From August to October:
  - If a systemic insecticide was not applied at planting, regularly (about twice weekly) check field margins for whiteflies; these areas are usually infested first.
  - If a systemic insecticide was applied at planting, check fields on a weekly basis. Begin checking twice weekly approximately 45 days after the application.
- From November through March, check field margins once weekly.
- Fields are commonly and uniformly infested in the low desert, but whiteflies may be more numerous along field margins during initial infestations.
- Be especially alert for rapid increases in whitefly numbers when nearby hosts are in decline or being harvested. During these critical periods, check cole crop fields twice weekly.

Yellow sticky traps may be useful in detecting initial whitefly migrations into fields. If using these traps, place them out of direct sunlight, with the sticky side facing the crop plants. Monitoring may also involve
turning over crop leaves, as whiteflies tend to be present on leaf undersides. This method may be more difficult, as whiteflies quickly disperse when disturbed.

Thresholds are not available for sweetpotato whitefly in cole crops. For organic cole crops or crops that did not receive an at-plant soil application of systemic insecticide, consider applying insecticide only to the field margins if whiteflies are more numerous at the field margins than the centers. This will reduce whiteflies and the costs of application, as well as help preserve natural enemies in the field. Applying insecticide to the field margins may not be necessary in cole crops that received an at-plant application of a systemic insecticide.

Rotate insecticides with different mode-of-action group numbers to manage resistance. This includes all insecticides used in the field for other pests during the current season. Maximize the efficacy of applications by achieving thorough spray coverage. Ground application may provide more complete coverage than aerial.

<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>A. CYANTRANILIPROLE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Exirel)</td>
<td>13.5–20.5 fl oz</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>(Verimark)</td>
<td>6.75–13.5 fl oz</td>
<td>4</td>
<td>NA</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Exirel is available for a foliar application; for best performance, use an adjuvant. Verimark is available for at-plant soil application (see label for more information). Verimark translocates into the canopy of transplants 1 to 3 days after application. Effective against adults.</td>
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<tr>
<td><strong>B. CHLORANTRANILIPROLE</strong></td>
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<td></td>
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<tr>
<td>(Coragen)</td>
<td>5–7.5 fl oz</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 28</td>
<td></td>
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<tr>
<td>COMMENTS: Foliar application; use with an effective adjuvant for best performance. Use higher application rates within this range for heavier infestations, larger or denser crops, or extreme environmental conditions such as rainy weather or high temperatures.</td>
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<td></td>
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<tr>
<td><strong>C. DINOTEFURAN</strong></td>
<td>See comments</td>
<td>12</td>
<td>See comments</td>
</tr>
<tr>
<td>(Venom)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Registered for use on broccoli, broccoliflower, Brussels sprouts, cabbage, cauliflower, Chinese cabbage, and kohlrabi. Not registered for use on cole crops grown for seed. Highly toxic to bees for more than 38 hours after application. For foliar application, application rate is 1–4 oz per acre and PHI is 7 days. For soil application, application rate is 5 oz per acre and PHI is 21 days. If a soil application is used, apply at planting. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.</td>
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<tr>
<td><strong>D. IMIDACLOPRID</strong></td>
<td>See comments</td>
<td>12</td>
<td>See comments</td>
</tr>
<tr>
<td>(Admire Pro)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER‡: 4A</td>
<td></td>
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</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.
COMMENTS: Highly toxic to bees. Not registered for use on cole crops grown for seed. Effective against nymphs only. May be used alone for light, moderate or heavy infestations. For foliar application, application rate is 1.3 fl oz per acre and PHI is 7 days. For soil application, application rate is 4.4–10.5 fl oz per acre and PHI is 21 days. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

E. ACETAMIPRID
   (Assail 70 WP) See comments 12 See comments
   MODE-OF-ACTION GROUP NUMBER: 4A
   COMMENTS: For head and stem cole crops, application rate is 1.1–1.7 oz and PHI is 7 days. For leafy cole crops, application rate is 1.1–2.3 oz and PHI is 3 days. May be used alone for light, moderate or heavy infestations. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

F. FLUPYRADIFURONE
   (Sivanto 200 SL) 10.5–14 fl oz 12 1
   MODE-OF-ACTION GROUP NUMBER: 4D
   COMMENTS: Reduces both eggs and nymphs.

G. SULFOXAFLOR
   (Sequoia CA) 4.25–5.75 fl oz 12 3
   MODE-OF-ACTION GROUP NUMBER: 4C
   COMMENTS: Reduces both whitefly nymphs and eggs. Highly toxic to bees; not registered for use on crops grown for seed.

H. THIAMETHOXAM
   (Actara) 3.0–5.5 oz 12 See comments
   MODE-OF-ACTION GROUP NUMBER: 4A
   COMMENTS: PHI for head and stem cole crops is 0 days, whereas for leafy cole crops it is 7 days. May be used alone for light, moderate or heavy infestations. Not registered for use on crops grown for seed. Thiamethoxam and its metabolites (which include the neonicotinoid clothianidin) are highly toxic to bees. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

I. BIFENTHRIN
   (Brigade 2EC) 2.1–6.4 fl oz 12 7
   MODE-OF-ACTION GROUP NUMBER: 3A
   COMMENTS: For light infestations, may be used alone. For moderate to heavy infestations, combine with spirotetramat (Movento) or spiromesifen (Oberon).

J. SPIROTETRAMAT
   (Movento) 4–5 fl oz 24 1
   MODE-OF-ACTION GROUP NUMBER: 23
   COMMENTS: Effective against nymphs. Use following an adulticide or with an adulticide (such as bifenthrin) if adult numbers are high.

K. SPIROMESIFEN
   (Oberon 2 SC) 7–8.5 fl oz 12 7
   MODE-OF-ACTION GROUP NUMBER: 23
   COMMENTS: Not registered for use on collards, kale, mizuna, or mustard greens. Effective against nymphs. Use following an adulticide or with an adulticide (such as bifenthrin) if adult numbers are high.

L. BUPROFEZIN
Sweetpotato Whitefly (12/20) 65
Illustrated version at ipm.ucanr.edu/agriculture/cole-crops/

(Courier SC Insect Growth Regulator)

MODE-OF-ACTION GROUP NUMBER: 16
COMMENTS: Controls nymphs but does not reduce eggs or adults. Good coverage is essential for control. Higher application rate may be necessary for rapidly growing infestations.

M. INSECTICIDAL SOAP

(M-Pede)# 1–2% (v/v) solution 12 0
MODE OF ACTION: Contact with smothering and barrier effects.
COMMENTS: This insecticide has no residual activity and requires frequent applications and thorough coverage. May be phytotoxic on Brussels sprouts and cabbage. Not as effective as other insecticide options. Check with organic certifier to determine which products are organically acceptable.

N. NARROW-RANGE OILS

(Omni Oil 6)# See comments 12 0
COMMENTS: Application rate per acre is 1 to 2 gallons in 100 gallons water (1–2% solution by volume). This insecticide requires frequent applications and thorough coverage. Check with organic certifier to determine which products are organically acceptable.

... OR ...

(Organic JMS Stylet-Oil)# 3–6 qt/100 gal water 4 0
COMMENTS: For cabbage and cauliflower only. This insecticide requires frequent applications and thorough coverage. Not as effective as other insecticide options. Check with organic certifier to determine which products are organically acceptable.

Organic Options (Efficacy research may be lacking on these products)

A. HEAT-KILLED BURKHOLDERIA SPP. STRAIN A396 CELLS AND SPENT FERMENTATION MEDIA

(Venerate)# 4–8 qt 4 0
MODE OF ACTION: biological (bacterial entomopathogen)
COMMENTS: Option for organic growers. Most effective on whitefly nymphs, but requires two sprays to be effective. Check with organic certifier to determine which products are organically acceptable.

B. ISARIA FUMOSOROSEA APOPKA STRAIN 97

(PFR-97 20% WDG)# 2 lb 4 0
MODE OF ACTION: biological (entomopathogenic fungi)
COMMENTS: Registered for use on broccoli, Chinese broccoli, Brussels sprouts, cabbage, Chinese cabbage, cauliflower, kale, and kohlrabi. Option for organic growers. May require at least two sprays of the high label rate to be effective against whiteflies. Most effective on nymphs. Does not reduce whitefly eggs. Check with organic certifier to determine which products are organically acceptable.

† 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 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 are assigned by IRAC (Insecticide Resistance Action Committee).

# Acceptable for use on organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.
**WIREWORMS** (12/20)

*Scientific Names: Limonius spp.*

**DESCRIPTION OF THE PEST** Wireworms are slender, cylindrical, brown-to-yellow larvae that grow to 0.5 to 1.25 inch long depending on the species. They are the soil-dwelling larvae of click beetles. Adult beetles are hard-bodied, black to tan, and about 0.25 to 1 inch long. When adults are upside down, they can flip their body into the air, making a pop or snap sound.

**DAMAGE** Wireworms devour seeds, clip off seedlings and small roots, and bore into roots and underground stems. Damage is more common in spring-planted crops where the soil is high in organic matter, such as fields that have recently been in or adjacent to alfalfa, pasture, or uncontrolled weeds. Wireworms do not significantly damage older plants.

**MANAGEMENT** After seedling emergence or right after transplanting, check the crop for wireworms, especially in spring-planted crops and where soil or that of the border areas is high in organic matter. Soil fumigation and some pesticides applied to control other pests will also kill wireworms, but pesticide application specifically for wireworms is seldom necessary. Preplant pesticide application or seed treatments in fields with a history of wireworm damage provide superior control compared to any postemergence practice.

**Cultural Control**

Destroy plant residue from previous crops and weeds around field borders. Fallow fields for several weeks before planting cole crops to allow organic matter to decompose.

<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.

**Seed Treatment**

A. CLOTHIANIDIN (NipsIt Vegetables)
   
   Label rates
   
   MODE-OF-ACTION GROUP NUMBER‡: 4A
   
   COMMENTS: Registered for use on only broccoli seeds in California, but seed treated in and obtained from another state can be legally used in California even if the chemical is not registered on the crop in California. Contact your retail seed dealer for information and availability. Application rate per seed depends on the amount of seed planted per acre.

**Preplant**

A. CLOTHIANIDIN (Belay)
   
   9-12 fl oz
   
   MODE-OF-ACTION GROUP NUMBER‡: 4A
   
   Phillips, CA.
COMMENTS: Use as a preplant or at-plant soil application (rate included above is for soil application only). Highly toxic to bees for more than 5 days after an application. This product has potential to leach into groundwater where soils are permeable, particularly where the water table is shallow.

B. DIAZINON
   (Diazinon 50W) 6–8 lb 96 (4 days) NA
   MODE-OF-ACTION GROUP NUMBER: 1B
   COMMENTS: Preplant or transplant water application only (see label for more information). Not registered for use on kohlrabi, mizuna, mustard spinach, and rape greens. Avoid drift and tailwater runoff into surface waters.

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Diseases

ALTERNARIA LEAF SPOT (11/08)

Pathogens: Alternaria brassicae, Alternaria brassicicola

SYMPTOMS AND SIGNS

The two Alternaria species, A. brassicae and A. brassicicola, cause similar symptoms. Small, dark specks first develop on leaves and later enlarge into circular, tan spots (0.25-0.5 inch in diameter). The spots caused by A. brassicicola tend to be darker than those caused by A. brassicae. If conditions are favorable, dark green spores of the pathogen will grow on the spots. Such growth causes the spots to have concentric rings in them. Old leaf spots become papery in texture and may tear. When the dry tissue falls out, a shot hole effect results.

COMMENTS ON THE DISEASE

Alternaria leaf spot is usually not an economic concern on cole crops. It occasionally is a problem on cabbage during cool, rainy months. The pathogen can also infect Brussels sprouts, broccoli, and cauliflower. Leafy crucifers that are harvested for their leaves (red mustard, Chinese cabbage, tat tsoi, and mizuna mustard) are also susceptible to Alternaria brassicae and can be seriously damaged by this pathogen. Disease is favored by moist conditions. Spores are spread by winds and splashing water. The fungus does not survive in soil but is carried over in crucifer seed, on weeds or volunteer hosts, or on undecomposed crop residue.

MANAGEMENT

Use clean seed and practice crop rotation. Fungicides applied as foliar sprays will control this disease.

<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>IPRODIONE (Rovral)</td>
<td>2 pt</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER¹): Dicarboximide (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: For broccoli only. Apply immediately after thinning (2- to 4-leaf stage) as a directed spray to the base of the plant and adjacent soil surface.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHLOROTHALONIL (various products)</td>
<td>Label rates</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER¹): Multi-site contact (M5)</td>
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<tr>
<td>COMMENTS: Use at 7- to 10-day intervals.</td>
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</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 the 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 action. Fungicides with a different group number are suitable to alternate in a resistance management program. For fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17, make no more than one application 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 a fungicide with a different mode-of-action group number.
**BACTERIAL BLIGHT** (6/07)

*Pathogen: Pseudomonas syringae pv. alisalensis*

**SYMPTOMS AND SIGNS**
Bacterial blight infections start as small, angular-shaped, water-soaked specks on leaves that are often surrounded by yellow borders. As the disease develops, specks enlarge and coalesce together into larger, irregularly shaped gray-to-tan spots. Leaf spots are visible from both top and bottom sides of leaves. Symptoms may resemble those of the more familiar bacterial leaf spot disease.

**COMMENTS ON THE DISEASE**
Recent research has identified this bacterial disease, which is caused by a pathogen related to, but distinct from, the bacterium that causes bacterial leaf spot. For cole crops, bacterial blight has been found on broccoli, cauliflower, and Brussels sprouts. Other crucifer hosts include rapini, arugula, and rutabaga. The pathogen is seedborne and is splashed from plant to plant by rain and sprinkler irrigation. Bacterial inoculum may persist for short periods of time in soil.

**MANAGEMENT**
Plant clean and disease-free transplants. Rotation away from fields where the disease has recently occurred may reduce inoculum levels in soil or infected debris. A change from sprinkler to furrow or drip irrigation may limit its spread.

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**BACTERIAL LEAF SPOT** (6/07)

*Pathogen: Pseudomonas syringae pv. maculicola*

**SYMPTOMS AND SIGNS**
Bacterial leaf spot infections start as small, dark specks on leaves. As disease develops, numerous water-soaked leaf spots appear. Leaf spots remain small (0.125 inch or 3 mm in diameter). Older leaf spots turn tan and may or may not have a purple border around them. Leaf spots are visible from both top and bottom sides of leaves. Symptoms on transplants may resemble downy mildew symptoms.

**COMMENTS ON THE DISEASE**
Bacterial leaf spot is most often seen under greenhouse conditions. Occasionally, it also occurs on cauliflower in coastal valleys, but its occurrence in production fields is sporadic. The pathogen is seedborne and is splashed from plant to plant by rain and sprinkler irrigation.
MANAGEMENT
Plant clean seed and disease-free transplants. Rotation away from fields where the disease has recently occurred may reduce inoculum levels in soil or infected debris. A change from sprinkler to furrow or drip irrigation may limit its spread. Cultivars vary in susceptibility.
BLACK LEG  (11/08)
Pathogen: Phoma lingam

SYMPTOMS AND SIGNS
The most serious symptoms occur on stems near the soil line where elongated, sunken, brown lesions form. These lesions may girdle the stem, resulting in stunting, wilting, and general poor growth of the plant. If the lesions enlarge, the stem may break, causing the plant to fall over. Lesions usually contain minute, spherical, dark structures that are the fruiting bodies of the pathogen. If conditions are right, pink masses of spores exude from these structures. If seedlings are infected early, they may die. Less important are the leaf spots that may develop on foliage. Leaf spots are circular, light tan, and contain the dark, spherical fruiting bodies of the pathogen. The disease damages the water-conducting tissue, and blackened streaks of xylem can be seen by cutting open the stem.

COMMENTS ON THE DISEASE
Of particular importance is the ability of this pathogen to be carried in and on seed. This is how the fungus is introduced into greenhouse and field plantings. The pathogen can live in crop debris if such material is not fully decomposed. Cool, moist conditions enhance disease development. Spores are spread with splashing water. A second spore type may occur that can be blown long distances on wind currents.

MANAGEMENT
Black leg can be managed by using disease-indexed seed, by cultural practices, and with foliar sprays. Remove cruciferous weeds and volunteer plants that may harbor the pathogen. Plow under debris in diseased fields to allow for more rapid and thorough decomposition. Practice crop rotation; rotate infested fields out of cruciferous crops for 1 or 2 years.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Example trade name)</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. IPRODIONE (Rovral) 2 pt 24 0
   MODE OF ACTION GROUP NAME (NUMBER): Dicarboximide (2)
   COMMENTS: Registered for broccoli only. Use as a foliar treatment applied as a directed spray to the base of the plant. If conditions persist, a second application may be made. Do not make more than two applications per crop. Effective against the black leg pathogen in other Brassica crops outside of California, but no research has been done in California to test its effectiveness on broccoli.

‡ 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.

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BLACK ROT (6/07)
Pathogen: Xanthomonas campestris pv. campestris

SYMPTOMS AND SIGNS
Black rot symptoms vary depending on the environmental conditions. Early in disease development, typical symptoms consist of angular or V-shaped chlorotic lesions along the leaf edges. With time these lesions will dry up and turn tan or brown. Black veins are often seen within these tan lesions, though they may not always develop. Severely infected leaves may wither and drop off the plant. If systemic infection has taken place, the vascular tissues in petioles and main stems can also turn black. If temperatures are cool, however, symptoms may not be expressed. Atypical symptoms, such as small, brown specks, may also occur and mimic other bacterial diseases.

COMMENTS ON THE DISEASE
The most severe losses from black rot have occurred in cabbage and cauliflower; crucifers grown for seed production crops can also be severely damaged. Black rot development is favored by warm, humid conditions. Splashing water from rain or sprinklers spreads the pathogen from plant to plant. Xanthomonas campestris pv. campestris is introduced into greenhouse or field situations primarily on seeds. The bacterium can also survive in soil if infected plant residues have not decomposed. Many cruciferous weeds are important reservoirs of the pathogen.

MANAGEMENT
Because the pathogen may survive in infected plant debris, do not plant a crucifer crop more often than every 2 years in any infested field. When possible, implement crop rotations using nonhosts. Some resistant cabbage cultivars are available.

Many cruciferous weeds host bacteria and must be controlled to prevent continued contamination. Remove weed and volunteer crucifers from production areas. Deep plowing can speed decomposition of infected plant debris, but care must be taken to bury all debris. Avoid sprinkler irrigation wherever possible, and do not plant infested fields during winter and spring when heavy rainfall occurs.

The bacterium can be carried on or in the seed. Plant seed that is free from the pathogen. Seed should be assayed to determine cleanliness and can be hot water treated to reduce infestation; however, hot water or other treatments are not 100% effective and may reduce germination. Transplants produced for field planting should likewise be disease-free. Clipping or mowing transplants before planting may result in widespread contamination of transplants.

Organically Acceptable Methods
Crop rotation, the use of resistant cultivars, weed management in the field and surrounding areas, and the use of pathogen-free seed and transplants are acceptable management strategies in an organically certified crop.
CLUBROOT  (6/07)
Pathogen: *Plasmodiophora brassicae*

SYMPTOMS AND SIGNS
During initial stages of clubroot, aboveground symptoms may be absent. When present, foliar symptoms consist of stunting, yellowing, wilting, and other signs of a dysfunctional root system. Extensive galling, swelling, and distortion of the roots and hypocotyl are the main symptoms of the disease. Galled and clubbed roots are often invaded by secondary rot organisms such as soft rot bacteria; this results in the rapid decay of roots, further decline of infected plants, and release of additional inoculum into the soil.

COMMENTS ON THE DISEASE
Clubroot infects all of the cole crops, as well as many weeds in the mustard family. The fungus persists in soil as thick-walled resting spores that can remain viable for 10 years or longer. Infection is favored by acid soils with adequate moisture, but infections do occur above pH 7.0. In the presence of host plant roots, these resting spores germinate by releasing swimming zoospores. Such zoospores infect and colonize root hairs. Later, a second type of zoospore appears that can infect the main roots. Infection and colonization by this second zoospore causes the galling and clubbing of roots. Additional resting spores are formed inside the galled roots and are released into the soil when roots decay. The fungus is dispersed from field to field by the use of diseased field-grown transplants and movement of infested soil on machinery and surface water.

MANAGEMENT
Once in the soil, clubroot fungus remains viable for many years. There is no economical way to eliminate it. Rotation with nonhost crops generally does not provide effective control; however, a 2-year rotation away from crucifer crops and into cereals may be helpful in some instances.

Minimize the spread of the pathogen by using pathogen-free transplants. It is preferable to use transplants that are produced in soilless rooting mixes in trays. However, if field-grown transplants must be used, then grow transplants in fumigated plant beds; young plants can be infected for some time without indicating infection and cannot always be detected at transplanting.

Restrict the movement of contaminated soil (on farm implements) from infested to noninfested fields. Do not use tailwater from contaminated fields to irrigate noninfested fields because the fungus can be transported in water.

Where fields are already infested with the clubroot pathogen, applying lime to infested fields can help create soil conditions unfavorable for spore germination. In general, apply lime if soil pH is lower than 7.2. Annual applications are usually necessary. Not all soils respond favorably to this treatment.

Organically Acceptable Methods
Crop rotation, proper handling of transplants and irrigation water, and liming the field are acceptable management tools in an organically certified crop.
DOWNY MILDEW (11/08)

Pathogen: Peronospora parasitica

SYMPTOMS AND SIGNS
Infections begin as irregular yellow patches on leaves; these chlorotic lesions later turn tan to light brown. If conditions are favorable, white fluffy growth of the fungus develops on the undersides of leaves. If disease development is extensive, leaves may take on a blighted effect as a result of numerous infection sites. Systemic infections can cause internal black streaks and patches to form in stems and floret branches of broccoli and cauliflower. Early symptoms on transplants may resemble bacterial leaf spot symptoms. Severely diseased seedlings may be stunted or die.

COMMENTS ON THE DISEASE
Peronospora parasitica requires cool, moist weather for infection and disease development to take place. The pathogen survives between crops on weed hosts or as resilient oospores in crop residue. Spores are airborne. This disease is most serious on young seedlings; if cotyledons and the first true leaves are severely infected, the young plant may die.

MANAGEMENT
A few broccoli varieties are available that are resistant to downy mildew. Fungicide treatment of susceptible varieties is needed when the disease occurs on transplants or early in crop development in the field; repeated applications may be required, depending on weather. Treatment during early flowering is required on seed crops.

Organically Acceptable Methods
Resistant varieties and some copper sprays are suitable for organically grown crops.

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>(Example trade name)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A. CHLOROTHALONIL
   (various products)
   LABEL RATES
   MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M5)
   COMMENTS: Use at 7- to 10-day intervals, if necessary.

B. MEFENOXAM/CHLOROTHALONIL
   (Ridomil Gold/Bravo 76.5)
   1.5 lb
   MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M5) and phenylamide (4)
   COMMENTS: Use at 14-day intervals, if necessary.

C. FOSETYL-ALUMINUM
   (Aliette)
   LABEL RATES
   MODE-OF-ACTION GROUP NAME (NUMBER): Phosphonate (33)
   COMMENTS: Use on a 7- to 21-day intervals as necessary. Do not tank mix with copper compounds.

D. COPPER#
   (various products)
   LABEL RATES
   MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M1)
   COMMENTS: Not all copper compounds are approved for use in organic production; be sure to check individual products.

Illustrated version at http://www.ipm.ucanr.edu/agriculture/cole-crops/
## Downy Mildew

### Common name (Example trade name)

<table>
<thead>
<tr>
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# Acceptable for organically grown produce.

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Illustrated version at [http://www.ipm.ucanr.edu/agriculture/cole-crops/](http://www.ipm.ucanr.edu/agriculture/cole-crops/)
FUSARIUM YELLOWS  (11/08)
Pathogen: *Fusarium oxysporum* f. sp. *conglutinans*

SYMPTOMS AND SIGNS
In California, this pathogen affects primarily cabbage. Symptoms consist of yellowing of the lower leaves, often on one side of the plant. These leaves later turn brown and drop off. A brown discoloration of the water-conducting tissues (xylem) is characteristic of this disease. With time the entire plant may yellow, wilt, and collapse.

COMMENTS ON THE DISEASE
Once present, this fungus survives indefinitely in the soil. The pathogen may be introduced to noninfested locations by the movement of infected plant residues and infested soil adhering to farm equipment. This disease causes more severe symptoms on summer crops due to warmer soil temperatures; *Fusarium* develops most rapidly at temperatures ranging from 75° to 85°F (24° to 29°C); little development occurs below 60°F (16°C).

MANAGEMENT
Avoid introducing the pathogen to clean fields. In areas where the fungus is known to occur, plant cabbage in spring or winter. Some resistant cabbage cultivars are available. However, there are several races of the pathogen, some of which may render these cultivars susceptible and generally, resistance diminishes with increases in soil temperature. For *Fusarium*-infested fields, consider rotating cabbage with crops that use preplant fumigation, such as strawberry; risk of *Fusarium* yellows should be significantly reduced in such situations.
PHYTOPHTHORA ROOT ROT (11/08)

Pathogen: Phytophthora megasperma

SYMPTOMS AND SIGNS
The external surfaces and internal tissues of infected roots are water-soaked, dark in color, and rotted. Leaves (especially older ones) first turn purple-red, and later yellow, and then wilt. The plant may be stunted, and with time the entire plant wilts. The stem near the soil line may turn black and become soft.

COMMENTS ON THE DISEASE
Phytophthora root rot occurs on cauliflower, Brussels sprouts, and other crucifers in the coastal areas. It usually occurs only if cole crops are planted in poorly draining, fine-textured soils that are kept overly wet. Hence, root rot is most often found at low spots in the field or at the tail-end of irrigation runs. The fungus is a soil inhabitant that survives in the soil for long periods.

MANAGEMENT
Control is difficult, but soil management that improves drainage, such as planting high, well drained beds, and carefully irrigating to avoid prolonged saturation of the soil, will reduce chances of infection. Because drought stress also makes plants susceptible to Phytophthora, ensure an even supply of moisture without major fluctuations to help suppress disease development. If a field has a history of Phytophthora disease problems, a treatment can be applied at planting.

<table>
<thead>
<tr>
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<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEFENOXAM (Ridomil Gold EC)</td>
<td>1–2 pt</td>
<td>48</td>
<td>0</td>
</tr>
</tbody>
</table>

A. MEFENOXAM (Ridomil Gold EC) 1–2 pt 48 0

MODE-OF-ACTION GROUP NAME (NUMBER¹): Phenylamide (4)

COMMENTS: Apply as a soil application at planting; can be preplant incorporated or applied as a soil surface spray after planting.

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RHIZOCTONIA DISEASES  (6/07)

Pathogen: Rhizoctonia solani

SYMPTOMS AND SIGNS
On cole crops, Rhizoctonia causes two types of disease symptoms: damping-off (or wirestem) and bottom rot.

Damping-off or wirestem occurs on newly emerged or very young transplants, when Rhizoctonia attacks the hypocotyl or lower stem tissue in contact with the soil. This results in browning and cracking of the epidermis and the formation of lesions. As infection progresses, the outer stem decays, leaving only the fibrous inner xylem intact (hence the name “wirestem”). Affected plants wilt, turn purple, and remain stunted. Seedlings may break off at the soil line. The pathogen can usually be identified by its coarse mycelia that often causes soil particles to adhere to and dangle from diseased stems.

Bottom rot is primarily a problem on cabbage, bok choy, and Chinese cabbage. Once head formation begins, lower leaves in contact with the soil may become infected with Rhizoctonia. Dark brown, oval lesions develop where soil touches the leaves. Secondary decay organisms may follow and make these lesions soft and watery. Infected leaves may wilt, exposing the head. Occasionally the pathogen may grow up into the inner tissues of the cabbage head.

COMMENTS ON THE DISEASE
Rhizoctonia solani is a common soil inhabitant that survives for long periods in soil and on crop residue as sclerotia. Wet, warm soils favor wirestem development. Seedling susceptibility decreases as plants mature.

MANAGEMENT
Prepare good quality seedbeds before planting. If possible, plant when soils are warm because seeds germinate faster and seedlings are more vigorous. Avoid excessively wet soils during early stages of seedling growth. If transplants are used, do not plant too deep if Rhizoctonia diseases are a problem in the field. No other control measures are recommended.
RING SPOT  (11/08)
Pathogen: Mycosphaerella brassicicola

SYMPTOMS AND SIGNS
In California, this disease occurs primarily on Brussels sprouts. Symptoms consist of circular http://ipm.ucanr.edu leaf spots (0.5 inch in diameter) that range in color from light brown to black. With time, these spots develop concentric rings, much like a target pattern. Small, spherical fruiting structures may also be observed within the leaf spots. If disease is severe, some defoliation may take place. This pathogen may also infect the sprouts, causing dark lesions on outer leaves.

COMMENTS ON THE DISEASE
The infection and disease development are favored by cool, moist conditions. Spores produced by this pathogen are spread by wind. Mycosphaerella brassicicola will persist in soil on infected plant residues only. There is some evidence that this pathogen may be carried on seed.

MANAGEMENT
Incorporate plant residues so that infected material decomposes fully. Remove volunteer plants that may be infected. Plant disease-free transplants. If ring spot is a problem in the area, use a protectant fungicide before infection takes place.

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. CHLOROTHALONIL
   (various products)  Label rates  12  7
   MODE-OF-ACTION GROUP NAME (NUMBER*): Multi-site contact (M5)
   COMMENTS: Use at 7- to 10-day intervals; multiple applications are needed (up to 4 maximum).

‡ 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.

* Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action.
Fungicides with a different group number are suitable to alternate in a resistance management program. For fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17, make no more than one application 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 a fungicide with a different mode-of-action group number.
**SCLEROTINIA DISEASES**  (6/07)

**Pathogens:** *Sclerotinia sclerotiorum, Sclerotinia minor*

**SYMPTOMS AND SIGNS**

Two species of *Sclerotinia* cause disease on cole crops. *Sclerotinia minor* only infects stems or leaves in close contact with the soil. Once infection takes place, water-soaked, brown, necrotic areas develop on these structures. The necrotic areas rapidly turn into soft, watery rots. Plants then wilt and collapse. Profuse amounts of white mycelial growth and numerous small (up to 0.125 inch or 3 mm), black, hard resting bodies called sclerotia, form on the outside and inside of the stems. *Sclerotinia sclerotiorum* can also infect lower leaves and stems, causing the same type of symptoms as *S. minor*. In addition, *S. sclerotiorum* forms tiny, brown, mushroomlike bodies (apothecia) that release aerial spores, which can infect any of the upper leaves and flowers. If conditions are right, these spores cause a watery, soft rot of these tissues as well. *Sclerotinia sclerotiorum* forms sclerotia that are larger (0.25–0.5 inch on average) than those of *S. minor*.

**COMMENTS ON THE DISEASE**

Sclerotia of both species enable the pathogens to survive in soil for a number of years without susceptible hosts. Wet soil conditions favor disease development. On crucifers, *S. sclerotiorum* tends to be the more important pathogen, while *S. minor* is only found infrequently. For *S. sclerotiorum*, cool and moist conditions are necessary for development of and infection by the spores. The aerial spores usually only infect injured or senescing leaves and flowers.

**MANAGEMENT**

Crop rotations and deep inversion plowing may be helpful in reducing severity of *S. minor* infections. Deep plowing or soil inversion reduces the number of sclerotia of *S. sclerotiorum* in the particular field, but has no effect on incoming aerial spores from surrounding fields and from long distances.

Chemical treatments are usually not required for Sclerotinia diseases in fresh market cole crops, but may be necessary in seed production fields. Currently only iprodione (Rovral) is registered for use on broccoli.
VERTICILLIUM WILT  (6/07)
Pathogen: Verticillium dahliae

SYMPTOMS AND SIGNS
The older, lower leaves of plants turn yellow and wilt. These leaves eventually turn brown and drop off the stem, usually when plants approach maturity. The water-conducting tissues (xylem) of the stems and roots become black. Overall growth of the plant may be stunted.

COMMENTS ON THE DISEASE
Verticillium wilt is usually a minor problem on cole crops. However, a more serious Verticillium problem occurs on cauliflower in coastal areas. Verticillium wilt symptoms are more prevalent on late-summer and early-autumn crops; cool soil temperatures favor infection and disease symptom development. The pathogen forms resistant structures (microsclerotia) that enable it to survive in soil for a decade or longer.

MANAGEMENT
Known infested fields should be planted to cauliflower only in winter or early spring. Some cauliflower cultivars may be more tolerant to Verticillium wilt than others. Avoid introducing the pathogen into clean fields. Planting broccoli, a nonhost of V. dahliae, may help reduce pathogen levels through a process called biofumigation: decaying broccoli residue, when disced into the soil, either gives off natural chemicals that can kill V. dahliae or alters the soil microflora so that V. dahliae survival is reduced.
WHITE RUST  (11/08)
Pathogen: Albugo candida

SYMPTOMS AND SIGNS
The fungus infects leaves and floral parts, causing distinctive white, raised pustules to form underneath the plant epidermis. These blisterlike pustules sometimes result in twisted, deformed growth of the stem, leaves, or flowers. When mature, the epidermis covering the pustule will rupture, releasing powdery white sporangia (a type of spore) that can be carried by winds or splashing water onto neighboring host plants. Severely infected leaves can wither and die.

COMMENTS ON THE DISEASE
The white rust pathogen of crucifers infects only plants in this host group, including arugula, bok choy, broccoli raab (rapini), Brussels sprouts, cabbage, cauliflower, Chinese cabbage, collards, Japanese or mizuna-type mustards, radish, tah tsai, and turnip. However, economic damage is only found on the crucifer crops in which the leaves are marketed. If free moisture and cool temperatures are present, the sporangia germinate by producing several smaller motile spores (zoospores) that swim and enter susceptible young tissues. Because A. candida is dependent on cool, wet conditions, the disease is consistently more severe during winter and early spring months. In addition to sporangia, A. candida also produces a second type of spore, the oospore, that can resist drying conditions and enable the fungus to survive in a dormant state in soil or crop residue. The white rust pathogen exists in the form of distinct races.

MANAGEMENT
White rust-resistant cultivars do not appear to be available for the host plants grown in California. Reducing leaf moisture by avoiding sprinkler irrigation will not prevent white rust, but keeping leaves dry may reduce disease severity. For sensitive crops such as arugula and rapini, avoid planting in fields that have a history of white rust problems; soilborne oospores may result in severe disease. Fungicides may be appropriate in some situations on leafy crucifer crops. The same fungicides that control downy mildews are also effective against white rust.

<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>MEFENOXAM (Ridomil Gold EC)</td>
<td>1–2 pt</td>
<td>48</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER¹): Phenylamide (4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply as a soil application at planting; can be preplant incorporated or applied as a soil surface spray after planting.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| MEFENOXAM/CHLOROTHALONIL (Ridomil Gold/Bravo 76.5) | 1.5 lb | 48 | 7 |
| MODE-OF-ACTION GROUP NAME (NUMBER¹): Multi-site contact (M5) and phenylamide (4) |

| FOSETYL-ALUMINUM (Aliette) | Label rates | 12 | 3 |
| MODE-OF-ACTION GROUP NAME (NUMBER¹): Phosphonate (33) |
| COMMENTS: Do not tank mix with copper compounds. |

| COPPER# | |

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. MEFENOXAM (Ridomil Gold EC)
B. MEFENOXAM/CHLOROTHALONIL (Ridomil Gold/Bravo 76.5)
C. FOSETYL-ALUMINUM (Aliette)
D. COPPER#
### White Rust

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre (various products)</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Label rates</td>
<td>See label</td>
<td>0</td>
</tr>
</tbody>
</table>

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

**COMMENTS:** Not all copper compounds are approved for use in organic production; be sure to check individual products.

‡ 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 organically grown produce.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with a different group number are suitable to alternate in a resistance management program. For fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17, make no more than one application 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 a fungicide with a different mode-of-action group number.
WHITE SPOT  (6/07)
Pathogen: *Pseudocercosporella capsellae*

SYMPTOMS AND SIGNS
This fungus causes circular, light tan leaf spots that are up to 0.5 inch in diameter. Sometimes dark streaks and splotches develop in the spots. If conditions are favorable, the characteristic white growth of spores may be observed on the leaf spots.

COMMENTS ON THE DISEASE
White spot is a relatively minor and infrequent disease on cole crops. Occurrence is often related to heavy winter rains. The pathogen does not persist in soil, but survives on weed hosts and volunteer crucifers. This pathogen also infects leafy crucifers such as red mustard and tat tsoi grown in coastal areas.

MANAGEMENT
No control measures are recommended.
**Nematodes** *(10/18)*

**Scientific Names:**
- Cabbage cyst nematode: *Heterodera cruciferae*
- Root-knot nematodes: *Meloidogyne incognita*, *Meloidogyne javanica*, *Meloidogyne arenaria*, and *Meloidogyne hapla*
- Sugarbeet cyst nematode: *Heterodera schachtii*

**DESCRIPTION OF THE PEST**

Plant-parasitic nematodes are microscopic roundworms that live in soil and plant tissues, and feed in or on roots. Several species may occur in the same field. Certain nematode species infest a wide variety of crops and other plants, while other nematodes are only able to feed on a few closely related plants.

Certain cyst nematodes and root-knot nematodes are pests of cole crops. The abundance and geographical distribution of each nematode species varies depending on cropping history, soil temperature, and soil type.

**DAMAGE**

Cyst nematodes occur in all cole crop-growing regions of California. They can severely damage any cole crop in any type of soil. Sugarbeet cyst nematode is more widespread in California than cabbage cyst nematode. High numbers of either species, particularly at seeding or transplanting, can stunt plants, reduce yields, and delay crop maturity.

When abundant, root-knot nematodes can cause significant yield reductions. They are most prevalent and damaging in moist, coarse-textured soils (sandy, loamy sand, and sandy loam), warm interior valleys, and warm-season crops. However, cyst nematodes cause the most damage to cole crops in California.

**SYMPTOMS**

Aboveground symptoms caused by nematodes are not diagnostic, because certain nutrient deficiencies, plant pathogens, and root-feeding insects cause similar symptoms. Symptoms of nematode infestation include yellowing of foliage and slowed or stunted growth. Infestations may also occur without causing any aboveground symptoms.

Cyst nematodes cause:
- patches of stunted or dying plants,
- yellowing of foliage, and
- reduction in head and curd size.

Cyst nematodes do not form root galls. With careful observation, the pinhead-size, lemon-shaped females are visible on root surfaces. Young females are white, then become brown and eventually turn into black cysts (egg-filled bodies).

Root-knot nematodes cause:
- Gnarled roots.
• Galls on roots:
  o *M. hapla* forms numerous spherical, small galls.
  o Other *Meloidogyne* species form galls that are irregular in shape and often coalesce.
• Slow or stunted growth beginning with the seedling stage.
• Patches of stunted plants apparent by midseason.
• Wilting occurs earlier in the day than noninfected plants during periods of moisture stress (e.g., warm and windy conditions).

FIELD EVALUATION
To make management decisions, it is critical to know which nematode species are present and how numerous they are in soil samples.

For root-knot nematodes, diagnostic laboratories usually report the number of second-stage juveniles (J2) per 100 cubic centimeters of soil, since only this stage can be identified in soil samples.

• Later stages (J3, J4, and adult females) are always embedded in roots.
• Eggs and first-stage juveniles (J1) may be present in soil, but their extraction is difficult.

For cyst nematodes, extraction techniques are targeted towards extracting the cysts themselves (which can be filled with eggs) from the soil. The extracted cysts may be squashed to release their eggs. Laboratories therefore report cyst nematode infestations as the number of cysts per 100 cubic centimeters of soil, or the number of cyst nematode eggs per gram of soil.

If a previous crop was damaged by nematodes, and soil testing reveals the presence of nematode species that are pests of cole crops, their numbers may be high enough to damage cole crops. Once nematodes have infested a field, continuous management is necessary.

If nematode presence or the species have not previously been identified, take soil samples and send them to a diagnostic laboratory for identification.

1. Divide the field into sampling blocks of not more than five acres. Each block should be as uniform as possible regarding cropping history, crop injury, or soil texture.
2. Take samples after harvest, or preferably just before harvest, within the root zone of the previous crop. Take several subsamples randomly from a block, mix them thoroughly, and make a composite sample of about 1 quart (1 liter) for each block.
3. Place the samples in separate plastic bags, seal them, and place a label on the outside with your name, address, location, and the current or previous crop and the crop you intend to grow. Any other relevant information (such as the type or date of last nematicide application, the type of crop injury observed, crop cultivar, soil type, etc.) should be included in your records, but is not needed by diagnostic laboratories.
4. If plants with symptoms are available, place the roots in the same bag with soil.
5. Keep samples cool (do not freeze), and transport as soon as possible to a diagnostic laboratory.
6. Contact your cooperative extension advisor to help you use the best sampling procedures for your situation, find a laboratory for extracting and identifying nematodes, and for help in interpreting the test results.
MANAGEMENT
Sanitation
Prevent nematodes from moving into noninfested fields by doing the following:

- Thoroughly clean all equipment with water to prevent the spread of the nematodes in plant residue and soil.
- Do not allow irrigation or rainwater to flow from an infested field to other fields; impound or properly divert runoff.
- Prevent animal grazing and movement from infested fields into noninfested fields.

Cultural Practices
To increase crop tolerance to nematode feeding, reduce plant stress with proper fertilization and irrigation (see the production guides in the More Information section for more details). Plow under infested plants after harvest to prevent further reproduction of nematodes. Control weed hosts of these nematodes, including pigweeds (hosts of sugarbeet nematode) and weedy mustards.

Crop Rotation
Cyst nematodes have a relatively narrow host range and can be managed by rotation with nonhost crops. Crucifers are the only hosts for cabbage cyst nematodes. Sugarbeet cyst nematodes are hosted by crucifers, beets, spinach, and weeds in those plant families.

The higher the nematode numbers at harvest, the longer the period of rotation required to reduce nematode numbers before planting a susceptible crop. In Southern California, several years between host crops may be necessary. Longer rotations may be necessary in Northern California. See <Sugarbeet Pest Management: Nematodes for more details.

Crop rotation is not very effective against root-knot nematodes because of their wide host range. Strawberry may be a suitable rotation crop in fields with root-knot nematodes because they are nonhosts to M. incognita and most populations of M. javanica. The northern root-knot nematode, M. hapla, does reproduce on strawberry.

Nematicide Application
Economic thresholds have not been established for nematodes in cole crops. Decide whether to apply a nematicide by doing the following:

1. Examine roots for presence of cyst nematodes or root galls before harvest.
2. Consider applying a nematicide whenever the nematodes listed as pests of cole crops are present in the field.

Contact your local UC Cooperative Extension advisor for advice on a specific situation. Nematicide efficacy varies depending on the method of application and soil conditions at the time of application.
Common name (Example trade name) | Amount per acre | REI‡ (hours) | PHI‡ (days)
---|---|---|---
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.

PREPLANT
A. **1, 3-DICHLOROPROPENE§/CHLOROPICRIN§**  
   (InLine)  
   Label rates  
   See label  
   NA  
   COMMENTS: Multi-purpose liquid fumigant for the preplant, drip-irrigation treatment of soil for garden symphylan, plant-parasitic nematodes, and certain soilborne pathogens. Use of a tarp seal is mandatory for all applications of this product. Fumigants such as 1, 3-dichloropropene are a prime source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

B. **1, 3-DICHLOROPROPENE§**  
   (Telone EC)  
   9–18 gal  
   See label  
   NA  
   COMMENTS: Liquid fumigant for the preplant, drip-irrigation treatment of soil for plant-parasitic nematodes and certain other soil pests. Fumigants such as 1, 3-dichloropropene are a prime source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

C. **ETHOPROP**  
   (Mocap 15% Granular)  
   0.9 lb/1000 ft of row (15 inches wide) or 34 lb/acre broadcast  
   See label  
   NA  
   COMMENTS: Only registered for cabbage. Mix into the top 2 to 4 inches of soil right after application. Do not allow granules to contact crop seed.

PREPLANT, AT PLANTING, or POSTPLANT
A. **MYROTHECIUM VERRUCARIA STRAIN AARC-0255 FERMENTATION SOLIDS AND SOLUBLES**  
   (DiTera DF)#  
   Label rates  
   4  
   0  
   COMMENTS: Maintains crop health, growth and nutrient uptake in the presence of nematode infestations. Apply through the irrigation system or banded at the base of the plant. Rates indicate the total amount of product that was applied regardless of band width. Can be combined with fertilizers. If applied through the irrigation system, inject after the filter. Best results are obtained if the product is applied after the soil is saturated, during the last 15 to 20 minutes of the irrigation. Then flush the system with just enough water to clear the solution out of the irrigation system.

‡ 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 organically grown produce.

§ Do not exceed the maximum rates allowed under the California Code of Regulations Restricted Use Materials Requirements, which may be lower than maximum label rates.
Weeds

INTEGRATED WEED MANAGEMENT  (10/19)

Weeds compete with cole crops for nutrients, sunlight, and water. Weeds in and around the field sometimes harbor pest insects, nematodes, plant pathogens, or vertebrates that can invade or move to the crop after planting.

Weed control is especially important in precision-planted crops, where loss of seedlings to competition can substantially reduce the vigor and uniformity of the stand. Also, any weeds that mature to flowering can contribute to the soil weed seed bank and become weed problems in subsequent crops.

Cole crops are either direct-seeded or transplanted in the field. Brussels sprouts and cauliflower are primarily transplanted. In comparison with direct seeding, transplanted crops mature earlier in the field, have a more uniform stand, and need less weed management.

In direct-seeded crops, weed control is especially important during the first 30 days after planting. As the crop grows older, most cole crops compete well with weeds and shade them out.

There are also regional differences in weed problems:
- In cool, moist coastal areas, winter annual weed conditions are favored most of the year.
- In the southern desert, early fall plantings compete with weeds that germinate during warm conditions, and later fall plantings compete with winter annual weeds.
- In the San Joaquin Valley, grass weeds and early fall and winter weeds are most common.

It is important to rely on both cultural and chemical methods (integrated control) to keep weed numbers tolerable. Integrated management of pest insects, nematodes, and plant pathogens also contributes to successful weed management; damage and stunting due to other pests weakens the crop, making it less likely to outcompete weeds.

Irrigation Management
Throughout the season, manage irrigation carefully to improve the control of weeds and other pests:
- Keep furrows well maintained to prevent them from collecting water. Ponding water favors the growth of weeds with wind-dispersed seeds, water-loving weeds, and soilborne plant pathogens.
- Regularly monitor for uniformity and adjust sprinklers or drip systems to prevent uneven distribution of water.
  - Poor irrigation uniformity stresses patches of the crop and impairs the ability to outcompete weeds.
  - Regularly inspect and maintain emitters and lines for clogs and leaks.
- Skillfully schedule low-volume irrigation. Excess water can favor weed growth. Use CropManage to keep track of irrigation scheduling.
Herbicide Considerations

Herbicides may be applied before planting (preplant), after planting and before the crop emerges (postplant preemergence), or after planting and after crop emergence (postplant postemergence). Most herbicides used in cole crops control only weeds germinating from seeds. Herbicides can vary in effectiveness depending on field conditions and the targeted weed species. In some growing regions, fall-planted cole crops may receive a layby application (after the crop is well established) applied at the last opportunity for access to the field. The choice of timing depends on your schedule and the effective method for the particular herbicide and problem weeds in your field. For example, many preemergence herbicides are activated by sprinkler or drip irrigation, so the timing of the first irrigation may be the most important determinant of when to apply herbicide.

Herbicide choice depends largely on the weed species to be controlled, but is influenced by crop rotation, irrigation method, and soil type. Relatively few herbicides are available for use in cole crops, and the registered products are weak on key weeds such as shepherd’s purse and common groundsel. Herbicides also vary in selectivity and potential for damaging the crop (phytotoxicity). When trying a new herbicide, or if you suspect that an herbicide may be damaging the crop, leave representative parts of a row untreated, to use in later comparison of weed efficacy or crop sensitivity. For more information on herbicide damage to nontarget plants, see UC ANR's Herbicide Symptoms diagnostic tool.

Many of the herbicides used in cole crops do not kill emerged weeds, and in these situations, it is best to cultivate soil to kill emerged weeds before making an herbicide application. An exception is oxyfluorfen, registered for postemergence application in broccoli and cauliflower. Other postemergence herbicides may control only grasses or require use of a hooded sprayer to shield the crop while controlling broadleaved weeds.

No single herbicide provides satisfactory control of all weeds; combinations of herbicides or sequential applications and cultivation and hand weeding will often be required. Check with your cooperative extension advisor or agricultural commissioner for the latest information on available herbicides and their compatibility and recommended rates.

Proper application is as important as the right choice of herbicide for controlling weeds without injuring the crop.

- Use application equipment suited to field conditions.
- Calibrate sprayers before each use.
- Test the pH and hardness of water used for the spray solution and adjust if needed.
- Know your soil type and adjust the application rate accordingly. Lower rates are usually recommended or required for sandy soils for the following reasons:
  - Sandy soils have fewer binding sites for herbicides than do clay soils. Herbicides are therefore more available to be taken up by plants’ roots in these soils than they are in clay soils.
  - Herbicides are more effective at lower rates in sandy soils because herbicide uptake by weeds is higher.
It is important to time herbicide application relative to rain or irrigation for optimal efficacy and minimal potential for off-site movement and contamination. Rain or irrigation can increase the potential for runoff and leaching, and some herbicides lose effectiveness when leached or otherwise moved from the soil. However, application of preemergence herbicides must also generally be followed by appropriate irrigation or adequate rainfall to activate the herbicide. For herbicides requiring a post-application irrigation, take care to not overirrigate; about 1/2 inch of water during the first irrigation is often appropriate. If rainfall is insufficient to activate the herbicide, irrigation or mechanical incorporation will be necessary.

**MONITORING**

The type of weed management program depends mostly on the weed species present, where they are located, and how numerous they are. Survey each field for weeds:

- before harvesting the preceding crop,
- after planting but before the first cultivation, and
- between heading and harvest.

When surveying, identify, rate, map, and record the summer annuals, winter annuals, and perennial weeds.

To conduct a weed survey:

1. Walk through the field in a regular grid pattern. Also check the areas surrounding the field.
2. Rate the degree of infestation for each species on a weed survey form. Small weed seedlings may be difficult to identify, so scan the area for larger plants that are easier to identify. Use a numerical scale, or rate infestations as light, medium, or heavy.
3. Record what species of weeds are mature and producing seeds or other propagules; these weeds will be problems in succeeding crops.
4. Mark the main weedy locations on a map or use a GPS and computerized database such as GIS (geographic information system) to map weeds, if available. Take detailed notes of perennial weeds and other special weed problems to facilitate targeting of the separate practices needed for these weeds.

Maintain these records for each field to track long-term trends in weed species and infestation severity to help you assess the effectiveness of your management program and determine whether modifications are needed.

The recommended surveys, especially during weed monitoring in the previous crop, tell you where to apply specific weed control methods that are effective for the targeted weed species. For example, perennial weeds generally require different management than annual weeds.

**WEED MANAGEMENT BEFORE PLANTING**

Weed control is easier and less expensive in fields not infested with difficult-to-control weeds. Problem weeds include:

- common chickweed
- common groundsel
- cruciferous weeds such as mustards, London rocket, and shepherd’s-purse
prickly lettuce
little mallow
burning nettle
hairy nightshade
black nightshade
nutesedges
common purslane
sowthistles

If problem weeds are numerous, the best strategy is to rotate to a crop that allows successful control. For example, yellow nutsedge in coastal areas may be best controlled by rotating to a crop that receives preplant fumigation, such as strawberry.

**Fallow**

Sanitation is critical for effective weed management, and fallow is an important time to clear out weeds. Certain weeds, such as purslane, shepherd’s-purse, and burning nettle, can produce thousands of seed per individual weed in a single season. To reduce seed production, disc or mow fallow fields before weeds flower and produce seeds. To reduce weed seed dispersal into fields, regularly control weeds in areas such as fence lines, field edges, irrigation ditches, and roadsides.

Keep cultivation equipment and irrigation water free of weed seeds and vegetative propagules to avoid spreading weeds. Wash equipment with high-pressure water before leaving weedy areas or entering fields. Screen surface water sources of irrigation to avoid applying weed seeds in irrigation water.

Controlling weeds in fallow beds helps to reduce weed infestations in production fields. Emerged weeds on fallow beds can be controlled by shallow cultivation with a Lilliston® cultivator. Postemergence herbicides such as paraquat, glyphosate, pelargonic acid, and the combination of caprylic acid and capric acid can also be used to control emerged weeds on fallow beds. However, neither paraquat nor glyphosate completely control burning nettle, field bindweed, little mallow (cheeseweed), or nutsedge. Pelargonic acid and the combination of caprylic and capric acids will control little mallow.

Mechanically control *Conyza* (horseweed and fleabane) biotypes that are resistant to glyphosate, or use other herbicides with a different mode of action in fallow fields and nearby areas. Check herbicide efficacy two weeks after application to identify resistant weeds and control them before they produce seeds.

**Deep Plowing**

Plow deeply to bury weed seeds and perennial weed propagules below the depth at which they can germinate or regrow. The viability of buried seeds and propagules declines over time. Wait a longer interval before subsequent deep plowing (3–5 years) to reduce the number of buried weed seeds that will still be viable when brought back to the surface. Deep moldboard plowing 16 inches below the soil surface can temporarily reduce nutsedge infestations by 95 to 98%.
Plowing to bury seeds is not as effective against weeds that have hard-coated seeds, such as little mallow. These seeds can survive buried for years at greater depths and will germinate when they are brought to the surface by subsequent plowing.

**Crop Rotation and Field Sanitation**
Excellent weed control during the previous crop reduces the weed seed bank and makes the field less weedy over time. Keep areas around fields free of weeds that have aerially dispersed seeds such as groundsel and sowthistle. Clean equipment and tools before leaving weedy areas or entering fields. Screen surface water before irrigating with it to avoid applying weed seeds.

**Cover Crops**
Avoid slow-growing winter cover crops that allow substantial weed growth that sets seeds during early growth of the cover crop. Plant fast-growing cover crops, or if slow-growing cover crops must be used, use higher seeding rates to allow them to better compete with weeds. For example, Indian mustard (*Brassica juncea*), cereal rye (*Secale cereale*), and white mustard (*Sinapis alba*) can be used as winter cover crops and can provide complete ground cover within 30 days of planting, as long as an adequate seeding rate is used to favor rapid ground cover and uniform establishment. See *Cover Cropping for Vegetable Production*, ANR Publication 3517 (PDF), and the UC Davis Cover Crops Database for more information.

Drill cover crops in closely spaced rows (about 6 inches apart) to help ensure rapid canopy closure of the cover crop. This is generally preferable to broadcast seeding, as it does not require as much seed. If broadcast seeding must be used to plant the cover crop, use higher seeding rates to obtain adequate coverage.

Cover crops provide a variety of benefits, but also have the potential to increase weed pressure in subsequent crops. Annual weeds frequently establish in the cover crop; depending on the species, weeds can grow, set seed, and decompose while the cover crop is present. They can be difficult to detect and manage, and may go unnoticed, substantially contributing to the weed seed bank and causing the cover crop to act as a nurse crop for weeds. Monitor cover crops, particularly during the first 40 days after seeding; ensure they are not creating a weed problem for subsequent plantings.

Though relatively uncommon, cover crops can also be grown on beds at spacing typical for growing vegetables and cultivated to control weeds. Use cultivation equipment such as rotary hoes or tyne weeders that disturb the top few inches of soil to control weeds after the cover crop is established. At this time, the roots of weed seedlings will be smaller and more vulnerable to shallow tillage than the more deeply rooted cover crops.

**Cultivation and Bed Preparation**
Control wind-dispersed weed species in areas surrounding the field before they flower, if possible. Preplant plowing of fields, followed by irrigation and one or two discings before bed formation, will destroy many weeds. Because plowing brings buried seeds to the surface, it must be followed by rain or preirrigation to germinate a flush of weed seed, and then followed by cultivation, discing or spraying of the emerged weeds before they flower.
Shallow cultivation can significantly reduce problem weeds such as common groundsel and sowthistle in the Central Coast region, and may also reduce certain soilborne plant pathogens. Cultivation should bury seeds of these weeds a few inches below the soil surface to prevent them from germinating.

Level the land before planting to avoid water collection in low areas, which favors weed growth. Precisely align and space beds and carefully align cultivators so that weed cultivation of bed tops is effective. Use GPS-assisted, auto-guidance systems to properly prepare and cultivate the beds.

**Pegermination of Weeds Before Shaping Beds**

This method involves germinating and controlling weeds before forming seed beds. Irrigate or await rainfall to induce weed seed germination, then kill emerged seedlings with shallow cultivation, plowing, flaming, an herbicide, or a combination of these methods. If time permits, repeat this method to further reduce the weed seed bank.

Conduct the final pregermination as close as possible to bed shaping and planting to ensure that the germinating weed spectrum (seasonal variation in weed species) does not change before planting. The season and weather affect when the seeds of each weed species germinate.

Time of year, irrigation method, and the interval between irrigation and weed control affect the efficacy of pregermination. Shallow tillage 14 days after preirrigation reduces weed germination in the subsequent crop up to 50%.

**Pegermination of Weeds After Shaping Beds (Stale Seedbed Method)**

This method provides substantial weed control to beds that are shaped and ready to plant. Weeds are controlled just before seeding or transplanting after seed bed formation. Similar to pregermination before bed formation, weeds are germinated with irrigation or rainfall. When using this method, weeds should be controlled with minimal disturbance of soil.

1. Prepare the soil as if you are about to direct seed or transplant. Once beds are ready to plant, irrigate to germinate weed seeds in the top inch of soil. Soil should be sufficiently moist to encourage germination of weed seeds.
2. Wait as long as possible for weeds to germinate and emerge. Allow weeds to grow to the third leaf stage, or at least to the first true leaf.
3. Once soil is dry enough to allow equipment on the field, control emerged weeds with shallow cultivation, flaming, or an herbicide.
   - Take care to not cultivate too deeply, otherwise additional weed seeds from deeper layers may be brought to the surface.
   - If transplanting, control weeds just before transplanting.
   - If direct seeding, control weeds before planting, just before crop emergence, or both if necessary, such as with direct-seeded broccoli.
   - Apply a preemergence herbicide at the appropriate time relative to field preparation and the age and species of crop. Application timing can vary depending on whether the preemergence herbicide is incorporated by cultivation or irrigation.
4. Otherwise, minimize soil disturbance for as long as possible after planting.
Soil Solarization
Cover moist, bare soil with clear plastic for at least 4 to 6 weeks during a sunny, warm time of the year to control many weed species, soil-dwelling insects, nematodes, and pathogens in the top few inches of the soil. This method is not often used in cole crops because of the high cost, short crop cycle, and limited number of times immediately before planting that weather is suitable for solarization. For more information, see Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds, UC ANR Publication 21377.

Flaming
Use flaming any time before the crop emerges. This method is less effective on grasses than broadleaves because the growing point for grasses is below the ground.

Flaming can be used with the stale seedbed method to control small emerged weeds. It can also be used in organic operations to control weeds on winter fallow beds when the soil is too wet to cultivate but dry enough to drive through the field with a tractor.

The flame causes the water in the plant to expand, which ruptures the cell walls. Weeds must have less than two true leaves for greatest efficacy. Typically, flaming can be done through fields at 3 to 5 miles per hour, although this speed depends on the heat output of the unit being used. Propane-fueled flammers are the most common models used.

Windless conditions achieve the best results for this method, as winds can prevent the heat from reaching the target. Early morning or evening are the best times to observe the flame for adjustment.

After flaming, weeds that have been killed change from a glossy to a matte finish. This occurs very rapidly in most cases.

Herbicides
Preemergence herbicides are applied before weeds emerge. If using herbicides, create a custom herbicide weed susceptibility chart for your field and use it to make the best herbicide selection for your situation. See the Herbicide Treatment Table for information on specific herbicides that can be used at this time.

Preemergence herbicides can be applied before direct seeding or transplanting. These herbicides usually require rainfall, irrigation or mechanical incorporation to be effective. Minimize soil disturbance during transplanting and for as long as possible after applying a preemergence herbicide. However, timely cultivation after weeds emerge may also be necessary. Transplants exposed to a properly applied preemergence herbicide may temporarily show leaf cupping or crinkling, but rapidly outgrow these symptoms if they are hardy and not severely stressed before transplanting.

Organically Acceptable Methods
The goals of organic weed management are to use organic-compliant practices and products to
- reduce weed infestations and weed seed production
- give the crop a competitive advantage over weeds
- produce the crop as economically as is feasible
Weed control in organic cole crops depends on the integration of good cultural practices, such as pregermination of weeds, sanitation, careful cultivation, and hand weeding. Cover cropping is a key cultural practice in many organic systems and should be done in a way that depletes the weed seed bank over time (see the Cover Crops section above). Additionally, the use of opaque plastic mulches on beds (with transplants in holes) can control weeds and reduce irrigation needs.

Practice sanitation in fields to prevent weed introduction by contaminated equipment, tools, transplants, and irrigation surface water. This will reduce the need for weed management during the current and subsequent crops.

It is very important to either plant cole crops in fields with few weeds or reduce weed pressure before planting. If possible, use transplants instead of direct seeding organic crops. This will establish the crop canopy more quickly and give it a head start on shading out weeds. Transplants also require fewer days to harvest and generally need only one weeding, whereas direct-seeded crops require two.

Cultivation can be used to control weeds any time before the crop is planted. Flaming can also kill weed foliage any time before transplanting or the emergence of direct-seeded crops, especially for crops that have slow germination. Flaming kills young broadleaf weeds with less than two true leaves, but grasses, perennials, and older broadleaves will generally regrow from belowground parts. Prior to planting (including during fallow periods), organic herbicides consisting of caprylic and capric acids can also be used to burn down flushes of weeds on fallow or stale beds. Because organic herbicides can be expensive, their cost should be taken into consideration when planning for their use.

**WEED MANAGEMENT AFTER PLANTING**

Control weeds during their critical seedling stage. Cole crops (with the exception of cabbage) compete well with weeds later in their crop cycle. However, some weeds (such as sowthistle) will grow taller than crop plants and continue to produce seed. Late-season weeding may be needed to reduce seed set and dispersal.

**Cultivation**

Cultivation typically controls weeds on 80% of a typical double-row, 40-inch bed. Good cultivation depends on precise alignment of cultivation knives around the uncultivated seed lines. When cole crops have two to three true leaves, sweeps or knives can be set as close as 2 inches on each side of the seed rows as long as they are set to cultivate shallowly; closer cultivation will cut crop feeder roots. Crowders can also be used to throw dirt to the base of the crop plant and bury small weed seedlings. On 40-inch beds with a single row of the crop (most often the case for cauliflower), there is more dirt to throw to the base of the crop plant, and burying weed plants is more effective. The thrown dirt both buries small weeds and prevents new weed seedlings from germinating.

Cut weed seedlings as close to the seed row as possible without disturbing the crop. Precision guidance systems such as Kult®, Steketee®, or Robocrop® use digital cameras and computer controls to shift the cultivator sled, which allows for more precise cultivation. The greater
precision of these machines removes a higher percentage of the weeds and allows the grower to confidently reduce the uncultivated band width.

To remove weeds in the seed line, hand weed or use special implements such as finger or torsion weeder. Finger or torsion weeder are most effective at killing small weed seedlings in the white thread stage. If timing is correct they can efficiently remove a high percentage of weeds in the crop row, greatly reducing subsequent hand weeding time. These devices are more suitable for transplants and timing is critical to remove the weeds when they are still small enough for the fingers to dislodge them from the soil.

Automated weeder are now available that use either a split knife or a spinning blade to remove weeds from the seed line without damaging the crop. These machines were designed for use in transplanted crops; although they are sometimes also used in direct-seeded crops, they are most effective for transplants. Because the transplants are initially larger than germinating weeds, the machines use the size difference to know which plants to remove and which plants to keep. They do not remove all weeds from the seed line but make subsequent hand weeding operations quicker and more efficient.

Fields may be cultivated two or more times between planting and harvesting depending on the crop, location and season:

- Most cauliflower and Brussels sprouts are transplanted at low planting densities (for example, a single seed line on a 40-inch wide bed), so multiple mechanical cultivations can control weeds for the entire cropping season.
- Broccoli is usually planted to a stand and not thinned. Hand weed or cultivate at least once if economically feasible.
  - For direct-seeded broccoli, cultivate at about the two- to three-leaf stage and again two weeks later. About 80% of the bed can be cultivated on double-row, 40-inch beds, assuming a 4-inch-wide strip along each seed line is left uncultivated. Soil can be crowded to the base of the plant on the second cultivation, smothering small weeds.
- In coastal areas, fall-planted cole crops may require more cultivation than summer-planted crops.
  - Cool temperatures slow crop growth; it may take 45 to 60 days for cole crops to shade out weeds and eliminate the need for further weed control.

Hand Weeding

Use a long-handled blade to cut weeds at or slightly below the soil surface to avoid mechanical damage to the delicate crop stems and roots.

Carefully hand weed when needed during the first 30 to 40 days after planting. Depending on weed pressure, hand weed one or two more times in direct-seeded cole crops. Employ the methods above before crop emergence or transplanting to reduce the time needed for hand weeding and improve its effectiveness.

Flaming

Flaming can be used after planting any time before the crop emerges. Weeds must have less than two true leaves for maximum effectiveness. Windless conditions achieve the best results for this
method, as winds can prevent the heat from reaching the target. Early morning and evening are
the best times to observe the flame for adjustment. Flaming is also less effective on grass weeds
than broadleaf weeds. Flame weeds at a pace of 3 to 5 miles per hour depending on the heat
output of the flamer.

**Surface Banding of Ammonium Nitrate Fertilizer**

Surface banding with ammonium nitrate is an effective way to apply nitrogen and gives the crop
a competitive advantage over weeds. The waxy cuticle that cole crops develop once they have at
least three true leaves prevents damage to the crop unless the plants are very wet. Because many
weeds lack this cuticle, the fertilizer will burn them, especially when applied on warm days. Use
a shielded sprayer to prevent application to the growing point or emerging new leaves of the cole
crop.

<table>
<thead>
<tr>
<th>Controlled</th>
<th>Partially controlled</th>
<th>Not controlled</th>
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<tbody>
<tr>
<td>chickweed*</td>
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<td>bindweed, field</td>
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<tr>
<td>little mallow (cheeseweed)</td>
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<td>goosefoot, nettleleaf</td>
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<tr>
<td>mustards</td>
<td></td>
<td>lambsquarters, common</td>
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<td>nettle, burning</td>
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<td>nutsedge</td>
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<td>rocket, London</td>
<td></td>
<td></td>
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<tr>
<td>shepherd's-purse</td>
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</tbody>
</table>

*Must be in the cotyledon to 2-leaf stage.

**Herbicides**

To determine which herbicide is most likely to be effective against the particular weed species
present, create a custom herbicide weed susceptibility chart for your field. See the Herbicide
Treatment Table for information on specific herbicides to use at this time.

**Organically Acceptable Methods**

After planting, use hand weeding, flaming, and cultivation in an organically certified crop.
Capric and caprylic acids may also be used after planting if applications are made with hooded
spray equipment to prevent crop injury.

Careful hand weeding is typically critical for effective weed control in organic cole crops.
However, transplanting instead of direct seeding reduces, and sometimes eliminates, the need to
hand weed after planting.
SPECIAL WEED PROBLEMS (10/19)

BURNING NETTLE
Burning nettle is a winter annual in the San Joaquin Valley and southern desert and grows throughout the year in coastal areas. This broadleaf produces abundant seed. Its irritation of skin on contact makes thinning and weeding work difficult and slow, increasing the cost of labor. Preplant applications of oxyfluorfen or trifluralin will control it.

COMMON CHICKWEED
Chickweed is a winter annual weed that is very competitive with cole crop seedlings. Preplant incorporated applications of napropamide control chickweed.

COMMON GROUNDSEL
Common groundsel is a winter annual broadleaf in most of California but can grow throughout the year in coastal areas. It is not a problem in the southern desert.

Use cultivation to bury viable groundsel seed a few inches below the soil surface. Groundsel seed can only emerge if within ½ inch of the soil surface.

Rotate to a crop for which registered herbicides provide effective control. Before planting, irrigate to germinate seed, then shallowly cultivate as close to planting as possible to reduce groundsel emergence in the crop. Throw dry soil as a dust mulch along the seed row during the first cultivation to reduce subsequent emergence of groundsel.

COMMON PURSLANE
Purslane is an annual broadleaf that grows rapidly in spring and summer. In addition to applying an effective preemergence herbicide, be sure to remove from the field uprooted plants where the soil surface is wet. Otherwise, uprooted purslane will reroot, continue to grow, and produce numerous seed.

CRUCIFEROUS WEEDS
These include but are not limited to weedy mustard species, London rocket, and shepherd's-purse. They are very difficult to control with herbicides because they are in the same plant family as cole crops. If these weeds are abundant, rotate to a crop where they can be easily controlled with herbicides.

LITTLE MALLOW
Also known as cheeseweed, little mallow is a winter annual broadleaf and occasionally a biennial or short-lived perennial. It is very competitive in cole crops and is common in coastal areas and in the southern desert. It germinates 1 to 2 inches deep in the soil, which allows it to escape preemergence herbicide applications.

Nitrogen fertilizer surface applications are very effective when applied to cheeseweed plants in the cotyledon to two-leaf stage. A pretransplant treatment of oxyfluorfen is effective against this weed. Applications of capric and caprylic acid can also be effective if applied to emerged
NUTSEDGES
Nutsedges are herbaceous perennials in the sedge family that superficially resemble grasses. Moist soil and warm, sunny conditions favor their growth. Nutsedge infestations can increase or spread via both seeds and tubers. However, in many regions, nutsedges do not produce viable seed, and tubers are the main source of increased or persistent infestations. Tubers are easily moved with soil, contaminating farm equipment.

Use specialized moldboard plows (such as Kverneland) to bury nutsedge tubers 16 inches deep. This can reduce nutsedge numbers by 95 to 98%. Tubers must be left deeply buried for at least 2 years before deep plowing again, otherwise this method will not be effective.

No herbicides are available to control nutsedge in cole crops. In infested fields, plant cole crops during cool weather, when nutsedge does not actively grow; during the summer, plant other crops in which nutsedge can be somewhat controlled with herbicides, such as beans, peppers, or tomato. In coastal areas, rotate to a crop that receives preplant fumigation, such as strawberry. Fumigation with metam products will control yellow nutsedge but will only partially control purple nutsedge.

Cultivation is the only method for removing nutsedge after planting cole crops. Cultivate nutsedge before it has four true leaves (before tuber production). Cultivating when plants are larger allows more tubers to form. Tubers persist in soil for long periods of time, and when the soil is warm, they sprout and produce aboveground growth that may interfere with subsequent crops.

PRICKLY LETTUCE
Prickly lettuce is a common winter annual or biennial broadleaf in the Central Valley and southern desert. It germinates after fall irrigations or winter rains. Napropamide and oxyfluorfen herbicides control prickly lettuce.

SOWTHISTLES
Sowthistle is a common winter annual that germinates throughout most of the year in coastal areas and from late fall to early spring in other locations. Napropamide and oxyfluorfen herbicides control this weed. Preplant cultivation can also provide some control. If this weed is not completely controlled early in the season, it can grow above the crop and produce and disperse seed later in the crop cycle.
# COMMON AND SCIENTIFIC NAMES OF WEEDS (10/19)

Common names link to pages with weed descriptions and photos often showing several stages of development.

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<th>Scientific Name</th>
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<td>volunteer grains</td>
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# SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL (10/19)

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<th>CAP</th>
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<td><strong>ANNUAL WEEDS</strong></td>
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<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>groundsel, common</td>
<td>N</td>
<td>—</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>N</td>
</tr>
<tr>
<td>knotweed, common</td>
<td>C</td>
<td>—</td>
<td>N</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>lambsquarters, common</td>
<td>P</td>
<td>C</td>
<td>—</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>P</td>
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<td>C</td>
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<tr>
<td>lettuce, prickly</td>
<td>N</td>
<td>—</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>—</td>
<td>N</td>
<td>P</td>
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</tr>
<tr>
<td>little mallow (cheeseweed)</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>mustards</td>
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<td>C</td>
<td>P</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td>N</td>
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<td>N</td>
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<tr>
<td>nettle, burning</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>—</td>
<td>N</td>
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</tr>
<tr>
<td>nightshade, black</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>—</td>
<td>N</td>
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<tr>
<td>nightshade, hairy</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>—</td>
<td>N</td>
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<tr>
<td>oat, wild</td>
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<td>—</td>
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<td>C</td>
<td>P</td>
<td>C</td>
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<td>pigweeds</td>
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<td>—</td>
<td>N</td>
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<td>C</td>
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<td>P</td>
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<td>C</td>
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<td>pineapple-weed</td>
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<td>—</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>—</td>
<td>P</td>
<td>P</td>
<td>—</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>polygogon, rabbitfoot</td>
<td>C</td>
<td>—</td>
<td>N</td>
<td>C</td>
<td>—</td>
<td>C</td>
<td>—</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>—</td>
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<tr>
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<td>N</td>
<td>N</td>
<td>C</td>
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<td>P</td>
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</tr>
<tr>
<td>radish, wild</td>
<td>N</td>
<td>—</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td>—</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>rocket, London</td>
<td>N</td>
<td>—</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>shepherd’s-purse</td>
<td>N</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>P</td>
<td>C</td>
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</tr>
<tr>
<td>sowthistles</td>
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<td>N</td>
<td>P</td>
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<td>—</td>
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<td>C</td>
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<td>C</td>
<td>C</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>C</td>
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<tr>
<td><strong>PERENNIAL WEEDS</strong></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>bindweed, field (seedling)</td>
<td>N</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>P</td>
<td>—</td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>bindweed, field (established)</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>C</td>
</tr>
<tr>
<td>nutsedge, purple</td>
<td>N</td>
<td>—</td>
<td>N</td>
<td>N</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>
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</tr>
<tr>
<td>nutsedge, yellow</td>
<td>N</td>
<td>—</td>
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<td>N</td>
<td>P</td>
<td>C</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

**Herbicide Legend**

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

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Mode of action&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Mode of action&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEN</td>
<td>= bensulide (Prefar)</td>
<td>8</td>
</tr>
<tr>
<td>CAP</td>
<td>= caprylic and capric acids (Suppress)</td>
<td>un</td>
</tr>
<tr>
<td>CAR</td>
<td>= carfentrazone (Shark)</td>
<td>14</td>
</tr>
<tr>
<td>CLE</td>
<td>= clethodim (Select Max)</td>
<td>1</td>
</tr>
<tr>
<td>DCP</td>
<td>= DCPA (Dacthal)</td>
<td>3</td>
</tr>
<tr>
<td>GLY</td>
<td>= glyphosate (Roundup PowerMAX)</td>
<td>9</td>
</tr>
<tr>
<td>MET</td>
<td>= metam sodium* (Vapam)</td>
<td>17</td>
</tr>
</tbody>
</table>

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

<sup>1</sup> Group numbers are assigned by the [WSSA website](https://wssa.net/wssa/weed/herbicides/) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, use mode-of-action group numbers to plan mixtures or rotations of herbicides with different modes of action.

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Susceptibility of Weeds to Herbicide Control (10/19) 103
Illustrated version at [http://www.ipm.ucanr.edu/agriculture/cole-crops/](http://www.ipm.ucanr.edu/agriculture/cole-crops/)
### HERBICIDE TREATMENT TABLE (10/19)

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per 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>
</tbody>
</table>

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.

**FALLOW**

A. **CAPRYLIC AND CAPRIC ACIDS**
   (Suppress EC)# 6–9% (v/v) solution 24 NA
   WSSA MODE-OF-ACTION GROUP NUMBER: un
   COMMENTS: For nonselective burndown of weeds on winter beds. The smaller the weeds, the more effective the control. Low label rate of 3% not as effective as intermediate and higher rate. Thorough coverage is essential for effective control. Check with organic certifier to determine which products are organically acceptable.

B. **GLYPHOSATE**
   (Roundup PowerMAX) Label rates 4 NA
   WSSA MODE-OF-ACTION GROUP NUMBER: 9
   COMMENTS: Rate depends on weed species. Controls most annuals and partially controls many perennials. Does not completely control burning nettle, field bindweed, little mallow, or nutsedge. Apply to emerged weeds on winter beds. Seed into undisturbed soil for maximum effectiveness. Adding ammonium sulfate often enhances control in areas with hard water. Manage Conyza spp. (fleabane and horseweed) biotypes that are resistant to glyphosate using herbicides with a different mode of action.

C. **PARAQUAT*** 0.5–1.0 lb a.i.
   (Gramoxone SL 2.0) 2–4 pt 12 NA
   WSSA MODE-OF-ACTION GROUP NUMBER: 22
   COMMENTS: For preplant, preemergence use on broccoli, cabbage, Chinese cabbage, cauliflower, or collard fields only. Apply to emerged weeds on winter beds; this contact herbicide will control many seedling weeds. Addition of a surfactant is essential for good control. Controls most emerged annual weeds and grasses and burns back perennial weeds.

D. **PELARGONIC ACID**
   (Scythe) Label rates 12 NA
   WSSA MODE-OF-ACTION GROUP NUMBER: 27
   COMMENTS: For nonselective burndown of weeds on winter beds. The smaller the weeds, the more effective the control.

**PREPLANT (Direct-seeded crops)**

**Before weeds emerge**

A. **BENSULIDE** 5–6 lb a.i.
   (Prefar 4-E) 5–6 qt 12 NA
   WSSA MODE-OF-ACTION GROUP NUMBER: 8
   COMMENTS: Effective on a limited number of summer broadleaf and grass weeds. Not effective on volunteer grain crops. Apply preplant and mechanically incorporate 1 to 2 inches. Activate by drip or sprinkler irrigation. May be followed by sprinkler or furrow irrigation. Relatively insoluble in water and readily absorbs into organic matter, therefore leaching risks are low. Long residual period.

Illustrated version at http://www.ipm.ucanr.edu/agriculture/cole-crops/
### Herbicide Treatment Table

**B. DCPA**  
4.5–10.5 lb a.i.  
(Dacthal Flowable)  
6–14 pt  
12  
NA  
WSSA MODE-OF-ACTION GROUP: 3  
COMMENTS: Can be applied either before planting or at transplanting to control many broadleaf and grass weeds. Not very effective at controlling weeds in the mustard family (cruciferous weeds). Must be applied in a band application and incorporated as described on the label.

**C. NAPROPAMIDE**  
0.5–1.0 lb a.i.  
(Devrinol DF-XT Selective)  
1–2 lb  
24  
NA  
WSSA MODE-OF-ACTION GROUP: 15  
COMMENTS: Registered for use only on broccoli, Brussels sprouts and cauliflower. Can be preplant incorporated or applied postplant in direct-seeded and transplanted cole crops, but best used on transplants. This herbicide must be used with care on direct-seeded cole crops to avoid injury. Use lower rate on coarse-textured soils. Activate by drip or sprinkler irrigation. Provides excellent control of all annual grasses, including volunteer cereals and a large number of broadleaf weeds (including chickweed). Napropamide has a long residual period and therefore can carry over and injure rotational crops; do not plant certain crops, especially cereal grains, lettuce, and sugarbeets, following its use in cole crops.

**D. TRIFLURALIN**  
0.5–0.75 lb a.i.  
(Treflan HFP)  
1–1.5 pt  
12  
NA  
WSSA MODE-OF-ACTION GROUP: 3  
COMMENTS: Application rate varies by soil type. Effective on summer broadleaf and grass weeds. Preplant incorporation may be used for both direct-seeded and transplanted cole crops. Avoid use in cold, wet soils or under arid desert conditions. Must be mechanically incorporated 2 to 3 inches deep to remain effective. Can cause injury to cole crops under arid conditions in the southern desert and wet, cold winters in coastal areas (this herbicide is not widely used in these situations). Controls a limited spectrum of weeds (will control burning nettle) and has a long residual period. Residues may persist in the soil for up to 12 months, and are acutely harmful to sensitive crops, including corn, milo, spinach, and sugarbeet.

**PRETRANSPLANT**  
Before weeds emerge

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate</th>
<th>Application</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. DCPA</strong></td>
<td>4.5–10.5 lb a.i.</td>
<td>6–14 pt</td>
<td>Can be applied either before planting or at transplanting to control many broadleaf and grass weeds. Not very effective at controlling weeds in the mustard family (cruciferous weeds).</td>
</tr>
<tr>
<td><strong>B. NAPROPAMIDE</strong></td>
<td>0.5–1.0 lb a.i.</td>
<td>1–2 lb</td>
<td>Registered for use only on broccoli, Brussels sprouts and cauliflower. Can be preplant incorporated or applied postplant in direct-seeded and transplanted cole crops, but best used on transplants.</td>
</tr>
<tr>
<td><strong>C. OXYFLUORFEN</strong></td>
<td>0.125–0.5 lb a.i.</td>
<td>1–2 pt</td>
<td>Registered for use only on broccoli, Brussels sprouts and cauliflower. This herbicide is safer to transplants than to direct-seeded cole crops. Use lower rate on coarse-textured soils. May be either preplant incorporated or applied after transplanting. Activate by drip or sprinkler irrigation. Provides excellent control of all annual grasses, including volunteer cereals and a large number of broadleaf weeds (including chickweed). Napropamide has a long residual period and therefore can carry over and injure rotational crops; do not plant certain crops (especially cereal grains, lettuce, and sugarbeets) following its use in cole crops.</td>
</tr>
</tbody>
</table>

Illustrated version at [http://www.ipm.ucanr.edu/agriculture/cole-crops/](http://www.ipm.ucanr.edu/agriculture/cole-crops/)
WSSA MODE-OF-ACTION GROUP NUMBER: 14
COMMENTS: Registered for pretransplant use for broccoli, cauliflower, and cabbage. Do not use on Brussels sprouts. Apply to preshaped beds. If weeds are present, add a surfactant to enhance weed kill. The high rate is especially useful for hard-to-control weeds such as little mallow. Do not disturb the soil after treatment except for the transplanting operation. At least 1/4-inch rainfall or irrigation is needed after application to activate the herbicide. Sufficient water movement from the drip line across the bed is needed to incorporate oxyfluorfen for optimum efficacy and crop safety. GoalTender provides good control of many broadleaf annual weeds (including burning nettle and little mallow), with the exception of chickweed. It is less effective at controlling large lambsquarters, mustards, and weedy grasses. Does not control yellow nutsedge.

D. TRIFLURALIN
(Treflan HFP)  Label rates  12  NA
WSSA MODE-OF-ACTION GROUP NUMBER: 3
COMMENTS: Application rate depends on soil characteristics, the crop being grown, and whether the crop is transplanted or direct-seeded. Preplant incorporation may be used in both direct-seeded and transplanted cole crops. Preplant incorporate with rotary-powered equipment for bed planting; if planting flat (not on raised beds), shallow discing is acceptable. This herbicide is safer for transplanted cole crops than direct-seeded cole crops, but must be kept in the upper 2 to 3 inches of soil to minimize the chance of crop injury and maximize weed control. Will control burning nettle.

AT PLANTING
Before crop and weeds emerge
A. BENSULIDE  5–6 lb a.i.
(Prefar 4-E)  5–6 qt  12  0
WSSA MODE-OF-ACTION GROUP NUMBER: 8
COMMENTS: Can be applied preplant or postplant preemergence (direct-seeded crops only), before the crop and weeds emerge. If applying after direct-seeding, apply as a surface application and follow immediately with irrigation. Relatively insoluble in water and readily absorbs into organic matter, therefore leaching risks are low. Long residual period.

B. DCPA  4.5–10.5 lb a.i.
(Dacthal Flowable)  6–14 pt  12  0
WSSA MODE-OF-ACTION GROUP NUMBER: 3
COMMENTS: May be preplant incorporated or applied at direct seeding or transplant. Controls annual grasses and some annual broadleaf weeds. Not very effective at controlling weeds in the mustard family (cruciferous weeds). Banded application required. Incorporate with sprinkler irrigation. DCPA can be sprayed directly over transplants without injury. Application rates specific to soil type (see label).

C. NAPROPAMIDE  0.5–1.0 lb a.i.
(Devrinol DF-XT Selective)  1–2 lb  24  0
WSSA MODE-OF-ACTION GROUP NUMBER: 15
COMMENTS: Registered for use only on broccoli, Brussels sprouts and cauliflower. Labeled for use in both direct-seeded and transplanted cole crops but is safer to transplants than to direct-seeded cole crops. May be either preplant incorporated or applied posttransplant (or postplant preemergence for direct-seeded crops) followed by sprinkler irrigation. Use lower rate on coarse-textured soils. Activate by drip or sprinkler irrigation. Provides excellent control of all annual grasses, including volunteer cereals and a large number of broadleaf weeds (including chickweed). Napropamide has a long residual period and therefore can carry over and injure rotational crops; do not plant certain crops (especially cereal grains, lettuce, and sugarbeets) following its use in cole crops.

POSTPLANT

Illustrated version at http://www.ipm.ucanr.edu/agriculture/cole-crops/
## After crop and weeds emerge

<table>
<thead>
<tr>
<th>Herbicide Treatment Table (10/19)</th>
<th>107</th>
</tr>
</thead>
</table>

### A. CAPRYLIC AND CAPRIC ACIDS
(Suppress EC)# 6–9% (v/v) solution 24 0
WSSA MODE-OF-ACTION GROUP NUMBER¹: un
COMMENTS: For nonselective burndown of weeds. The smaller the weeds, the more effective the control. Low label rate of 3% not as effective as intermediate and higher rate shown above. Thorough weed coverage is essential for effective control. Use hooded sprayers or other equipment to avoid crop injury. Check with organic certifier to determine which products are organically acceptable.

### B. CARFENTRAZONE
0.016–0.03 lb a.i. 12 0
(Shark EW) 1–2 fl oz
WSSA MODE-OF-ACTION GROUP NUMBER¹: 14
COMMENTS: May be applied to the row middles using a hooded sprayer for control of some broadleaf weeds, including burning nettle, many cruciferous weeds, and little mallow. Take care to keep the spray off the crop.

### C. CLETHODIM
0.068–0.12 lb a.i.
(Select Max) Annual grasses: 9–16 fl oz Perennial grasses: 12–16 fl oz 24 30 14
Head and stem crops: Leafy crops: WSSA MODE-OF-ACTION GROUP NUMBER¹: 1
COMMENTS: Selective postemergence herbicide for control of annual and perennial grass weeds including annual bluegrass. Always apply with a crop oil concentrate. Apply after the crop and weeds emerge. Controls seedlings of annual grasses (later stages of annual grasses are more difficult to control) and certain perennial grasses, but not broadleaf weeds or sedges. Less effective when grasses are moisture stressed.

### D. SETHOXYDIM
0.188–0.28 lb a.i.
(Poast) 1–1.5 pt 12 14 30
WSSA MODE-OF-ACTION GROUP NUMBER¹: 1
COMMENTS: Selective postemergence herbicide for control of annual and perennial grasses, except for annual bluegrass. Not effective on broadleaf weeds or sedges. Apply when grasses are small and actively growing. Do not cultivate within 5 days before or 7 days after application. An oil adjuvant is needed to achieve consistent weed control. Rotational grass crops (such as cereal grains and turf) are susceptible. To control volunteer cereals (barley, corn, oats, rye, and wheat) apply before tilling.

### E. OXYFLUORFEN
0.125–0.25 lb a.i.
(GoalTender) Broadcast: 4–6 fl oz Direct: 4–8 fl oz 24 35
WSSA MODE-OF-ACTION GROUP NUMBER¹: 14
COMMENTS: For use on broccoli and cauliflower only as a broadcast postemergence application under a Special Local Needs Label (SLN No. CA-060023). Apply on direct-seeded crops when they have four true leaves, and to transplanted crops at least two weeks after planting. When properly applied, safe on transplanted broccoli or cauliflower. Can cause crop injury under cool, cloudy conditions and when the crop is stressed by other factors (see Special Local Needs label for more information). Do not apply with adjuvants or fertilizer, or tank-mix with other pesticides when applying postemergence. Controls emerged weeds such as little mallow, burning nettle, common purslane, nettleleaf goosefoot, and sowthistle, which are not burned back by fertilizer applications. GoalTender provides good control of many broadleaf annual weeds, with the exception of chickweed. It is less effective at controlling large lambsquarters, mustards, and weedy grasses. Does not control yellow nutsedge.

### F. PELARGONIC ACID
(Scythe) | Label rates | 12 | 0

WSSA MODE-OF-ACTION GROUP NUMBER: 27

COMMENTS: May be applied to the row middles using a hooded sprayer for nonselective burndown of annual weeds. The smaller the weeds, the more effective the control. Keep the spray off the crop to avoid crop injury.

† 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 in organically grown produce.

1 Group numbers are assigned by the [https://wssa.net/wssa/weed/herbicides/](https://wssa.net/wssa/weed/herbicides/) Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, use mode-of-action group numbers to plan mixtures or rotations of herbicides with different modes of action.

NA Not applicable.
Vertebrates

MANAGING VERTEBRATES (7/16)

Bird and mammal pests are found in and around virtually every cropping system in the state, although they may not always present a significant problem. In some crops, damage caused by birds generally results in a loss of a portion of the current crop but does not decrease future yield potential.

Some pests will chew or destroy flexible irrigation lines and emitters. Other pests will dig holes through the soil surface, thereby channeling surface irrigation water to undesired areas. Food safety also becomes an issue if pest residues come into contact with the marketable commodity.

Manage your fields in order to keep pest numbers low and to discourage new invasions so that significant damage does not occur.

- Before planting, remove vertebrate pests and destroy habitats (such as burrows) within the field boundaries. Preventive measures cost less and are more successful before planting, when one can easily see the pests or their habitats.
- Be aware of the location, as vertebrate pests can easily reinvade if the field is adjacent to rangeland, waterways, or unmanaged areas. It is much easier to manage vertebrate pests by implementing control measures on the perimeter versus inside.
- Baiting, fencing, fumigating burrows, shooting, and trapping are easier and usually more effective if employed before you plant instead of after.
- Where feasible, deep plow and disc to destroy burrows, disperse or kill resident populations, and reduce the risk of reinvansion by pocket gophers, voles, and (to a lesser extent) ground squirrels.

Guidelines for reducing vertebrate pest problems and making control more economical:

- Correctly identify the species causing the problem using damage signs, burrows or habitat, tracks, feces, etc.
- If feasible, alter the habitat to make the area less favorable to the pest species (e.g., eliminate cover crops and weeds or keep them mowed low.)
- Take early action and use the control methods appropriate for the crop and time of year. Consider the environment and nontarget species when choosing a control method.
- Establish a monitoring system to detect reinfestation so you can determine when additional corrective measures or controls are necessary.

A successful pest management program requires good records and regular monitoring. Some vertebrate pest populations can easily "explode" because of high reproductive rates and abundant food. Keep a record of the management procedures you use and their effectiveness. Good records will help you plan and improve future control strategies.
For most vertebrate pests, there is more than one control option for reducing numbers and damage. The following table summarizes the various control measures appropriate for common vertebrate pests. Details on how to use these controls are given in the individual pest sections.

<table>
<thead>
<tr>
<th>Pest</th>
<th>Habitat modification</th>
<th>Trapping</th>
<th>Baiting</th>
<th>Fencing</th>
<th>Tree guards</th>
<th>Frightening</th>
<th>Shooting</th>
<th>Fumigating</th>
<th>Repellents</th>
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<tr>
<td>Deer</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X^1</td>
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<td>X</td>
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<td></td>
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<tr>
<td>Pocket gophers</td>
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<td></td>
<td>X</td>
<td>X</td>
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<td></td>
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<tr>
<td>Rabbits</td>
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<td>X</td>
<td></td>
<td>X</td>
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<td>X</td>
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<tr>
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</tbody>
</table>

1 During hunting season or with a permit.
2 cottontails are relatively easy to trap. Jackrabbits are difficult to trap, but trapping may be useful.
3 Not all of these techniques will be effective for all species. More specific information can be found in the bird section.


Vertebrate control equipment and supplies (baits, fumigants, propane exploders, traps, etc.) are available at local retail outlets such as farm supply and hardware stores. In addition, some county agricultural commissioner’s offices make certain rodenticides and fumigants available to growers. For further information or sources of special control pesticides, consult your local Cooperative Extension advisor or agricultural commissioner’s office.

**Legal Aspects of Vertebrate Pest Management**

Under the California Fish and Game Code, if California ground squirrels, meadow voles, pocket gophers, eastern fox squirrels, roof rats, black-tailed jackrabbits, cottontail rabbits, American crows, house sparrows, starlings, and yellow-billed magpies are causing or are anticipated to cause crop depredation, the owner or tenant of a property may use lethal methods to remove them at any time.

For other pests such as deer, wild pigs, western gray squirrels, and most bird species, depredation permits are required for removal. However, these regulations can change at any time, so it is always a good idea to check current California Fish and Game Code (http://leginfo.legislature.ca.gov/faces/codes.xhtml) to ensure removal of a particular species is legal.

**Pesticides**

Only pesticides that are registered with the California Department of Pesticide Regulation (DPR) can legally be used for vertebrate pest control. Registered pesticides are listed in DPR’s databases that are available online (http://www.cdpr.ca.gov/). You may also contact
your county agricultural commissioner for current product registrations and the latest information on legal pesticide use, including current information on restrictions that apply to pest control activities in order to protect endangered species. *Follow label directions carefully* and understand the hazards when using poison baits and fumigants.

The U.S. Environmental Protection Agency (EPA) has placed restrictions on most rodenticides used to control vertebrates in agricultural production. The applicator must have a permit to purchase and use the product. These products will be identified with an asterisk (*).

**Trapping**

Trapping is often used to control vertebrate pests. Mark all traps clearly with the owner’s name and contact address or phone number. In California, trapping mammals, even for pest purposes, requires a trapping license issued by the California Department of Fish and Wildlife. However, rats, mice, moles, voles, and pocket gophers do not have this requirement. Additionally, you do not need a trapping license for ground squirrels or rabbits if trapping on your own property for pest control purposes. However, if trapping either of these species for profit (e.g., pest control operator), a trapping license is required.

**Protected Species**

In some areas of California, crop fields are located within the range of federally- and state-protected threatened or endangered species. Species likely to be of concern include the San Joaquin kit fox, several species of kangaroo rats, and, where burrow fumigants are used, the blunt-nosed leopard lizard, California red-legged frog, and California tiger salamander.

**Typical Guidelines**

Special guidelines apply to the use of toxic baits and fumigants for vertebrate pest control in these areas. These include

- Modification of ground squirrel bait stations to exclude protected species
- Restrict broadcast applications of bait
- Prohibit fumigation at certain locations or during some times of the year
- Require that applications be supervised by someone trained to avoid harming endangered species

Your county agricultural commissioner has the latest detailed maps that show the ranges of endangered species and the latest information on restrictions that apply to pest control activities in those areas. You can also get more information on endangered species regulations from the DPR website(https://www.cdpr.ca.gov/docs/endspec/index.htm).

For more information on vertebrate management, see the Vertebrate Pest Control Handbook online(http://vpcrac.org/about/vertebrate-pest-handbook/).
Birds (7/16)
Crowned sparrow: Zonotrichia spp.
Horned lark: Eremophila alpestris
House finch: Carpodacus mexicanus
House sparrow: Passer domesticus

DESCRIPTION OF THE PEST
Several bird species may cause serious problems in cole crop production in California.

Horned Lark
Horned larks are about 6 to 7 inches long, smaller than robins, but slightly larger than sparrows. They are brown to gray with a distinctive pattern of yellow, black, and white bands on the face and throat. Their name comes from the small tufts of erect, dark-colored feathers behind the eyes of mature males. From a distance, they appear to walk rather than hop, distinguishing them from finches and sparrows. They have high-pitched, distinctive songs and often sing while flying.

Horned larks are classified as migratory nongame birds. They may be controlled under the general supervision of the county agricultural commissioner or under a depredation permit from the U.S. Fish and Wildlife Service.

House Finch
House finches are highly adapted to human environments. House finches are typically 5 to 6 inches long and feed in small flocks. Male finches have a rosy-red or orange head, rump, and breast with brownish wings and back, and a brown streak on their sides. Females have the brown body and wings, but lack the red or orange coloration.

House finches are migratory, nongame birds, and can only be lethally removed with a depredation permit from the U.S. Fish and Wildlife Service or under supervision of the local county agricultural commissioner.

Sparrow
White-crowned and golden-crowned sparrows cause damage in California. Both are about 6 to 7 inches long. White-crowned sparrows have a distinct pink or yellowish bill, erect posture, gray throat and breast, and a visible crown streaked with black and white. Their call is a clear whistle. Golden-crowned sparrows are similar, except they have no white head stripes. A golden-yellow central crown stripe is prominent with black borders. Their call is three to five clear whistles. Overall, golden-crowned sparrows are less numerous and cause fewer problems than white-crowned sparrows.

Crowned sparrows are migratory, nongame birds, and can only be lethally removed with a depredation permit from the U.S. Fish and Wildlife Service or under supervision of the local county agricultural commissioner.
The house sparrow is a small (approx. 6 inches), stocky songbird with short legs and a thick bill. Male house sparrows have a black throat and white cheeks. The male has a reddish back and black bib, while the female is distinctly brown. The house sparrow is an invasive, exotic species, and as such, can be lethally removed at any time.

**DAMAGE**
Most damage occurs before seedlings have two or three true leaves. Crowned sparrows feed on seedlings and mature plants. Damage to lettuce and cole crop heads will make produce unmarketable.

- Birds can reduce stands in direct-seeded lettuce and cole crop fields by feeding on seeds and young seedlings.
- Seedlings may be nipped off, or small holes may remain in the soil where the entire seedling was pulled out.

Horned larks feed on seeds of wild plants and on insects in open grasslands. They move into lettuce and cole crops when natural forage is scarce or when the lettuce or cole crop is planted closely to their habitat. These birds feed mainly on seedlings (up to 3–4 inches tall) where they nip or completely pull plants out. They feed in flocks and can create bare spots in a lettuce field in a few hours. They tend to feed well out into the field and do not concentrate along fence rows or wooded areas.

In contrast, much of the damage from house finches and crowned sparrows occurs along the field edges where they feed. Although house finches feed primarily along the field edges, they are often seen in open areas and tend to scatter to high, open perches when alarmed.

**MANAGEMENT**

**Biological Control**
Natural predators such as raptors and bobcats will feed on some of the smaller bird species, although these numbers mean little for controlling such bird pests.

**Cultural Control**

*Habitat Modification*
Always consider habitat modification as a first step for controlling bird pests.

- Look for and eliminate brush or pruning piles, stacks of irrigation pipes, piles of boxes, etc., where birds may rest and nest.
- Consider removing roosting trees along perimeters to reduce bird invasion into fields.

However, there are few situations when habitat modification can be used to control high bird numbers. As such, alternative control methods will likely be needed.
Monitoring and Treatment Decisions

Count birds weekly to help you determine when damage will occur so you can take action early. This is particularly important to reduce damage to fruiting buds and newly sprouted row crops.

- Watch for bird movement into or within the field.
- Keep track of species, numbers, and location if you have had substantial damage in the past.

These records will help you plan control strategies in advance and assess the effectiveness of previous control actions.

Frightening Devices

Frightening devices can deter some species (e.g., crowned sparrows), but are less effective for others (e.g., horned larks, house finches, and house sparrows).

The most effective way to frighten birds from a field is to use a combination of noisemakers and visual repellents such as mylar streamers and "scare-eye" balloons. For example, scare-eye balloons may be attached to trees or posts that are next to electronic distress call devices. This combination may increase effectiveness over using either approach by itself. For maximum effectiveness, rotate from one type of frightening device to another and do not use one combination of devices for more than a week; otherwise, birds will become used to it.

Common noisemakers include roving patrols of bird bombs and shell crackers. Stationary devices such as gas cannons and electronic distress calls also provide relief. These stationary devices are most effective when you have at least 1 device per 5 acres and when they are elevated above the canopy.

Regardless of the approach used, pay attention to bird responses when using frightening devices. When birds no longer respond negatively to a specific approach, you must switch to a different frightening tactic to continue to scare birds out of the field. At best, an appropriate rotation of frightening devices will control bird pests for a few weeks. Therefore, only use these scare tactics when needed to prevent birds from habituating to these auditory and visual repellents. Additionally, once birds become accustomed to feeding in a field, frightening tactics become much less effective. Therefore, have frightening devices ready to implement before damage occurs so that birds can be deterred right at the onset of damage.

Shooting

Birds that invade in small numbers, such as scrub jays and magpies, can often be controlled by shooting. Check with California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and county agricultural commissioner officials before shooting any birds as depredation permits are often needed.

Where permissible, occasionally shooting at a few birds will increase the effectiveness of your noisemaking techniques, especially if noise makers go off at the same times as the
actual shots, because birds will begin associating loud noises with the real hazards of firearms.

**Trapping**
Trapping can be an effective way to control house finches, house sparrows, and crowned sparrows, especially if conducted over a relatively large area such as several fields. The most effective trap for these species is the modified Australian crow trap.

Successful trapping must take into account the behavior patterns of the birds being controlled. These traps use live birds as decoys to attract additional birds. Therefore, place traps in suitable locations with adequate food, water, shade, and roost locations to keep the trapped birds alive.

Trapping is best carried out by someone experienced with the technique. For house finches and crowned sparrows, trapping must be conducted under supervision of the county agricultural commissioner.

Trapped birds are usually euthanized through the use of a CO₂ chamber. Leave some birds alive to serve as future decoys.

**Repellents**
Chemical repellents rely on objectionable tastes, odors, or learned aversions to deter birds from consuming or damaging fruit.
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
Disperse of empty containers carefully. Never reuse them. Make sure empty containers are not accessible to children, unauthorized persons, pets, or livestock. 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 pesticides 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.

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.

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