Potato

PEST MANAGEMENT GUIDELINES · Publication 3463
Statewide Integrated Pest Management Program · University of California Agriculture and Natural Resources

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The UC IPM Pest Management Guidelines are available from:

- Online: http://ipm.ucanr.edu
- UC Cooperative Extension: County Offices
- University of California
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Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM website for information on updates.

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

To be used with Integrated Pest Management for Potatoes, UC ANR Publication 3316.
Year-Round IPM Program

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](https://example.com) for information on how to minimize the risks of pesticide use to water and air quality. Water quality can be impaired when pesticides drift into 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 both commercial and seed potato production fields in California. Details on carrying out each practice and information on additional pests can be found in the [UC IPM Pest Management Guidelines: Potato](https://example.com). Track your progress through the year with this annual checklist form. Color photo identification sheets and examples of monitoring forms can be found at the [forms and photo identification pages](https://example.com).

To be used with [Integrated Pest Management for Potatoes](https://example.com), UC ANR Publication 3316.

Preplant

About Preplant

- **Mitigate pesticide effects** on air and water quality.

**What should you be doing during this time?**

Consider [crop rotation](https://example.com) for reducing pathogens, harmful nematodes, and problem weeds.

Manage weeds in the previous crop.

- [Survey for weeds](https://example.com) and keep records (example [weed survey form](https://example.com) PDF).
- Also survey adjacent areas and crops for [problem weeds](https://example.com), host plants of green peach aphid, potato psyllid, and other insects or diseases, and volunteer potatoes.
- Control volunteer potatoes.

Avoid herbicides that leave carry-over residues which may affect potatoes.

Take soil samples to [assay for nematodes](https://example.com) and soilborne fungal pathogens immediately after harvest of previous crop.

Manage residue from the previous crop.
Manage weeds between crops.

- Irrigate to stimulate weed seed germination after previous crop, before field preparation.
- Cultivate or apply preemergence herbicide as needed to control weeds.

Analyze soil for fertility, physical constraints, and pH, which can affect common scab. Fertilize according to soil analysis results. Providing adequate fertility can help with early blight control.

Watch for wireworms, especially if there is a history of damage. Manage if needed according to the Pest Management Guidelines.

Consider soil fumigation for nematodes and some soilborne pests.

- Nematodes and Corky Ringspot
- Powdery scab
- Sclerotium stem rot
- Verticillium wilt
- Weed control (indirect benefit)

Make sure to check fumigant label for details on the minimum time required between application and planting to prevent crop damage.

Monitor vole activity in adjacent fields and non-crop areas. Implement baiting programs or install exclusionary fencing if needed to keep voles from moving into potato fields.

Order seed potatoes of desired cultivar and certification level.

Check seed tubers for tuberborne diseases and frost damage.

- Bacterial diseases (Bacterial ring rot, Soft rot)
- Black dot
- Common scab
- Fusarium dry rot
- Late blight
- Powdery scab
- Rhizoctonia stem and stolon canker (black scurf)
- Silver scurf

Follow proper handling procedures for seed tubers.

Consider seed treatments to reduce disease problems.

- Fusarium seed piece decay
- Rhizoctonia stem and stolon canker (black scurf)
- Silver scurf
Planting

About Planting

- Mitigate pesticide effects on air and water quality.

What should you be doing during this time?

Plant under appropriate soil temperature and soil moisture conditions to avoid the following:

- Bacterial soft rot and blackleg
- Fusarium seed piece decay

Based on field history, consider a soil-applied insecticide to control:

- Aphids
- Flea beetles
- Psyllids
- Wireworms

If possible, select insecticides for in-furrow or seed treatment applications rather than broadcast applications.

Consider in-furrow application of nematicide.

Consider applying fungicide in furrows at planting to reduce:

- Bacterial seed piece decay
- Fusarium seed piece decay
- Stem and stolon canker (black scurf)
- Silver scurf

Consider field edge plantings of habitat that provides floral resources for natural enemies (PDF) that help control pests in adjacent crops.

Preemergence

About Preemergence

- Mitigate pesticide effects on air and water quality.

What should you be doing during this time?

Apply preemergence herbicide if needed, according to the Pest Management Guidelines. Consider combining a hilling operation to kill weeds already emerged followed by the herbicide application.
Manage soil moisture to minimize:

- [Fusarium seed piece decay](#)
- [Bacterial soft rot and blackleg](#)
- [Stem and stolon canker (black scurf)](#)

**Emergence Through Row Closure**

**About Emergence Through Row Closure**

- [Mitigate pesticide effects](#) on air and water quality.

**What should you be doing during this time?**

Monitor [aphids](#) weekly (Klamath Basin only). Keep records (example monitoring form PDF) and manage if needed according to the Pest Management Guidelines.

Watch for [pests of foliage](#) including:

**Insects**

- Aphids
- Cutworms and loopers
- Psyllids
- Tuberworm
- Whiteflies

**Diseases:**

- Blackleg
- Early blight
- Late blight
- White mold

Note presence of pests or damage (example monitoring form PDF) and manage according to the Pest Management Guidelines.

Monitor for tuberworm adults (Central and Southern California).

- Put out [pheromone traps](#).
- Keep records (example monitoring form PDF).

Apply insecticide if needed according to the Pest Management Guidelines.

Use hilling to shape beds that facilitate tuber coverage during tuber bulking.

[Survey for weed emergence](#). Cultivate or apply [postemergence herbicide](#) as needed.
If white mold has been a problem in previous potato crops, apply fungicide at flowering according to the Pest Management Guidelines.

Consider fungicide application if there is a field history of pink rot, Pythium leak, or black dot.

Consider application of nematicides via chemigation based on degree day model of nematode lifecycle.

Irrigate as needed.

Apply fertilizer as needed according to soil and petiole tests. Avoid over- or under-fertilization (especially nitrogen).

**Row Closure to Maturity**

**About Row Closure to Maturity**

- Mitigate pesticide effects on air and water quality.

**What should you be doing during this time?**

Monitor aphids weekly (Klamath Basin only). Keep records (example monitoring form PDF) and manage if needed according to the Pest Management Guidelines.

Watch for pests of foliage, including:

**Insects**

- Aphids
- Cutworms and loopers
- Flea beetles
- Psyllids
- Tuberworm
- Whiteflies

**Diseases**

- Blackleg
- Early blight
- Late blight
- White mold

Note presence of pests or damage (example monitoring form PDF) and manage according to the Pest Management Guidelines.

Monitor for tuberworm adults. (Central and Southern California)
• Continue monitoring pheromone traps.
• Keep records (example monitoring form PDF).

Apply insecticides if needed according to the Pest Management Guidelines.

Based on field history, manage diseases according to the Pest Management Guidelines.

• Pink rot
• Pythium leak (Central and Southern California)
• Sclerotium stem rot (Southern blight)

If white mold has been a problem in previous potato crops, apply fungicide at full flowering according to the Pest Management Guidelines.

Manage soil moisture to avoid soil cracking, but avoid over-irrigation to prevent diseases.

Consider application of nematicide via chemigation according to nematode lifecycle and label recommendations.

Apply fertilizer as needed according to soil and petiole tests. Avoid over- or under-fertilization (especially nitrogen).

Survey for weed escapes or late-emerging weeds. Apply postemergence herbicide if necessary.

**Maturation and Harvest**

**About Maturation and Harvest**

• Mitigate pesticide effects on air and water quality.

**What should you be doing during this time?**

Where tuberworm can be a problem, use hilling as needed to keep tubers covered.

Monitor for late blight and early blight. Apply fungicide or vine-killing agent as needed (according to the Pest Management Guidelines) to control late blight before harvest and prevent tuber infections.

Look for Sclerotium stem rot and consider early harvest if present.

Irrigate as needed. Manage water for late-season weed control and to avoid disease.

Apply contact herbicide or desiccant as needed for complete vinekill and control of nutsedge and other weeds.
Allow tubers to mature and set skin after vine kill and before harvest.

Harvest at proper soil moisture and temperature.

Use careful harvesting and handling procedures to reduce bruising.

After harvest, observe crop for tuber rots, nematodes, and insect damage. Use these observations to decide how stored tubers will be handled and to assess the effectiveness of the season's pest management program before planning the next season's program.

Storage
About Storage
What should you be doing during this time?

Use proper sanitation in storage areas.

Treat tubers going into storage if there is risk of fusarium dry rot, silver scurf, or late blight infection and tubers are to be stored more than 3 months.

Use proper curing conditions at beginning of storage.

Maintain proper ventilation, humidity, and temperature.

Monitor stored tubers for pest problems:

- Bacterial soft rot
- Fusarium dry rot
- Late blight
- Pythium leak
- Pink rot
- Silver scurf
- Tuberworm

Piles with significant number of wet or rotten potatoes should be removed.

Avoid repeated pile disturbance.

Store at temperatures that prevent nematode multiplication if compatible with intended use.

Pesticide Application Checklist
When planning for possible pesticide applications in an IPM program, review and complete this checklist to consider practices that minimize environmental and efficacy problems.

Choose a pesticide from the UC IPM Pest Management Guidelines for the target pest considering:

- **Impact on natural enemies and honey bees.** For more information, see *Protecting Natural Enemies and Pollinators*.
- Potential for water quality problems using the *UC IPM WaterTox database*.
- Impact on aquatic invertebrates. For more information, see *Pesticide Choice*, UC ANR Publication 8161 (PDF).
- Chemical mode of action if pesticide resistance is an issue. For more information, see *Herbicide Resistance: Definition and Management Strategies*, UC ANR Publication 8012 (PDF).
- Endangered species that may be near your site. Find out using the Department of Pesticide Regulation's *PREScribe* program.

**Before an application**

- Ensure that spray equipment is properly calibrated to deliver the desired pesticide amount for optimal coverage.
- Use appropriate spray nozzles and pressure to minimize off-site movement of pesticides.
- Avoid spraying during these conditions to avoid off-site movement of pesticides.
  - Wind speed under 3 mph and 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. Pay attention to buffer zones.
- 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 treatment was effective.

Consider water management practices that reduce pesticide movement off-site.
• Consult relevant publications: *Protecting Surface Water from Sediment-Associated Pesticides in Furrow-Irrigated Crops*, UC ANR Publication 8403 (PDF).

• Consult the *Department of Pesticide Regulation Groundwater Protection Program (GWPA)* website for pesticide information and mitigation measures.

• Install an irrigation recirculation or storage and reuse system. Redesign inlets into tailwater ditches to reduce erosion. For more information, see these publications:
  - *Reducing Runoff from Irrigated Lands: Tailwater Return Systems*, UC ANR Publication 8225 (PDF).
  - *Reducing Runoff from Irrigated Lands: Storing Runoff from Winter Rains*, UC ANR Publication 8211 (PDF).

• Use drip rather than sprinkler or flood irrigation.

• Limit irrigation to amount required using soil moisture monitoring and evapotranspiration (ET).

• Consider vegetative filter strips or ditches. (For more information, see *Vegetative Filter Strips*, UC ANR Publication 8195 (PDF)

• Use polyacrylamide (PAM) tablets in furrow irrigation systems to prevent off-site movement of sediments.

**Consider management practices that reduce air quality problems.**

• When possible, reduce volatile organic compounds (VOC) emissions by decreasing the amount of pesticide applied, choosing low-emission management methods, and avoiding fumigants and emulsifiable concentrate (EC) formulations.

For more about mitigating the effects of pesticides see the Mitigation page.

Text updated: 8/19
General Management in an IPM Program

Crop Rotation

Avoid planting potatoes in the same field year after year. Proper crop rotations enhance soil fertility, help maintain soil structure, reduce certain pest problems, increase soil organic matter, and conserve soil moisture. Herbicides not available for use in potatoes can be used in certain rotation crops to control problem weeds. However, be sure to check these herbicide labels for any plant-back restrictions concerning future potato crops. Whenever possible, use rotations that reduce problem pests and avoid rotations that may increase them.

If your field is infested with pathogens or nematodes listed in the table below, consider choosing a listed nonhost crop. Although longer nonhost crop rotations are ideal, they often are not economically feasible. A rotation of lesser duration is still beneficial but to a lesser degree. In general, avoid solanaceous crops as rotation choices. Control volunteer potatoes and weeds in the rotation crop.

For winter annual weed control, choose a small grain crop and control these weeds with a suitable herbicide. Manage summer annual weeds by growing a small grain (Klamath Basin) or using corn as a rotation crop so that selective herbicides and cultivations can be used.

<table>
<thead>
<tr>
<th>Pest problem</th>
<th>Rotation cycle (years)</th>
<th>Rotation crop options and other comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diseases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacterial ring rot</td>
<td>1 +</td>
<td>Non-potato crop; control volunteer potatoes</td>
</tr>
<tr>
<td>Black dot</td>
<td>3 +</td>
<td>Nonsolanaceous crop; control solanaceous weeds and volunteer potatoes</td>
</tr>
<tr>
<td>Common scab</td>
<td>1 +</td>
<td>Cereals; green manure cover crops such as rye, millet, and oats</td>
</tr>
<tr>
<td>Late blight</td>
<td>1 +</td>
<td>Nonsolanaceous crop; control solanaceous weeds and volunteer potatoes</td>
</tr>
<tr>
<td>Powdery scurf</td>
<td>3 +</td>
<td>Nonsolanaceous crop; control solanaceous weeds and volunteer potatoes</td>
</tr>
<tr>
<td>Silver scurf</td>
<td>1 +</td>
<td>Nonsolanaceous crop; control solanaceous weeds and volunteer potatoes</td>
</tr>
<tr>
<td>Stem and stolon canker</td>
<td>2–3</td>
<td>Non-potato crop but not sugarbeet; control potato volunteers</td>
</tr>
<tr>
<td>Stem rot</td>
<td>3</td>
<td>Small grains</td>
</tr>
<tr>
<td>Verticillium wilt</td>
<td>2–3</td>
<td>Cereals, grasses, legumes; control weeds</td>
</tr>
<tr>
<td>White mold</td>
<td>1 +</td>
<td>Cereals, grasses; control weeds</td>
</tr>
<tr>
<td>Other Pests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wireworms</td>
<td>3 +</td>
<td>Alfalfa; control weeds</td>
</tr>
<tr>
<td>Columbia root-knot nematode</td>
<td>2 +</td>
<td>Sordan79 sudangrass, alfalfa (for race 1)</td>
</tr>
<tr>
<td>Northern root-knot nematode</td>
<td>2 +</td>
<td>Small grains</td>
</tr>
<tr>
<td>Southern root-knot nematode</td>
<td>2 +</td>
<td>Nematode-resistant tomato cultivars</td>
</tr>
<tr>
<td>Weeds</td>
<td>1 +</td>
<td>Control [problem weeds]</td>
</tr>
</tbody>
</table>

Text updated: 8/19
Harvest

Most potatoes are harvested by solid set harvesters that dig two or more rows at a time and load directly into bulk trucks, which carry the tubers to a packinghouse, processor, or storage facility. Where soil is free of rocks and clods, windrowers are frequently used, allowing the harvest of up to twelve rows at a time.

Preventing bruising is one of the most important considerations in a well-managed harvest operation. Blackspot and shatter bruise can seriously affect marketable yield if precautions are not taken to reduce them. Several factors are important in controlling bruising.

Soil moisture

Proper soil moisture at harvest helps reduce bruising. The water content of tubers affects their sensitivity to bruising. If their water content is low, they are sensitive to blackspot bruise; if it is high they are sensitive to shatter bruise. The right combination of moisture and temperature helps to minimize both kinds of bruising. Soil moisture of 60 to 80% of field capacity is generally recommended.

Soil temperature

The lower the soil temperature, the more susceptible tubers are to shatter bruising, especially when the temperature is below 50°F. Whenever possible, harvest when the soil temperature is above 50°F. Soils are warmest between 11 a.m. and 11 p.m. Harvest during these hours if soil temperature is likely to fall below 50°F at night. However, avoid harvesting when tuber pulp temperatures are above 60°F to reduce tuber rots in storage.

Equipment operation

Follow the recommendations for harvester operation in your area to reduce bruise injury. Use equipment that is in good repair, correctly adjusted, and operated by an experienced person familiar with local conditions. Important considerations are digger blade depth; reduction of "spill-out" losses at the digger blade; apron pitch, speed, and agitation; travel speed; drop heights; and control of "undersweep." Operate the primary chain at 1.1 times the travel speed (1.5 feet per second for each 1 mile per hour of tractor speed). Operate the other harvester chains at 0.6 to 0.8 times the travel speed (1 to 1.2 feet per second for each 1 mile per hour). Keep chains filled so the tubers have little space to bounce around. Use padding on equipment wherever bruising might occur. When unloading at storage facilities, keep drop heights to a minimum; use straw-filled bags on baffle boards and use mats underneath hoppers to cushion spilled tubers.

Instruments that measure bruising forces in harvesting and handling equipment can be used to correlate the measured forces with resulting bruising, and thereby identify specific locations where modifications are needed to reduce bruising.
Text updated: 8/19
Irrigation

Availability of soil water is a major factor that determines yield and quality of the potato crop. Too little water reduces yields, induces tuber malformations, or increases severity of common scab or Verticillium wilt after infection has occurred. Excess or poorly timed irrigation may reduce yields and quality, cause several disease problems in the field or in storage, or leach nutrients from the root zone. Fluctuations in water availability favor disorders such as second growth and brown center or hollow heart and sugar ends.

Efficient irrigation requires finding out how much available water the soil can hold. Available water is that portion of the soil water that can be withdrawn by plants. During the growing season, irrigation is needed when a certain proportion of the available water, the allowable depletion, has been used. The allowable depletion in a particular field varies according to soil type, stage of crop growth, amount of available water, weather conditions, and irrigation cost. Because potatoes are sensitive to water stress, the allowable depletion is no more than 30 to 40%. To minimize common scab infection, the allowable depletion is no more than 20% during tuber initiation.

Potatoes are a shallow-rooted crop; 90% of the roots grow in the top 12 to 18 inches of the soil. You can determine from the clay content and soil texture in the top 18 inches how much available water the soil can hold. For a soil profile that includes layers of different soil types, calculate the available water separately for each layer; then add them together to obtain the total available water in the rooting zone. Take salinity into account in estimating available water; if the soil or irrigation water contains high levels of salts, plants withdraw less water, so the available water will be less.

Sprinkler irrigation

Most potatoes are irrigated with sprinklers. Center pivot, wheel line, and solid set systems are most commonly used. Sprinkler systems are more versatile than furrow irrigation systems and can apply fertilizers and some pesticides effectively. Uniform water application is most easily achieved with sprinkler systems. Sprinklers are readily adapted to uneven ground. When preparing fields, be sure not to leave any low spots where water will collect.

Sprinkler irrigation provides conditions in the potato canopy that are favorable for certain diseases, such as early blight, late blight, bacterial stem rot, and white mold. To reduce spread of these diseases, allow foliage to dry between irrigations. An advantage of center pivot irrigation systems is that the water applied is added relatively quickly to the plants. However, regardless of irrigation technique, watering during late afternoon or early evening may allow foliage to stay wet all night, providing a favorable environment for late blight. Allowing solid set sprinklers to run more than 6 hours, regardless of the time of day, has the same effect. Also, foliage near the middle of center pivot circles tends to remain wetter and more prone to foliar diseases and produces poorer quality potatoes, so this area should not be planted.
**Drip irrigation**

Drip irrigation systems are the most efficient, typically requiring 10 to 20% less water than sprinklers. The risk of foliar diseases is lower with drip systems, and they can apply fertilizers and some pesticides effectively. However, drip systems may create challenges with tillage and harvest operations and are particularly challenging when used on very coarse soils. Mite infestations may increase with the use of drip irrigation. The expense of drip systems generally makes them uneconomical for commercial potato production.

**Subirrigation**

Subirrigation can be used where the water table can be raised easily, soil is of uniform texture and structure, and fields are relatively level. The low, flat, peat soils of the Sacramento and San Joaquin Delta area of California are favorable for the use of subirrigation, but the lack of a high degree of soil uniformity makes other irrigation systems more advantageous.

**Preirrigation**

Soil moisture should be at 60 to 80% of field capacity at planting time. If rainfall is not adequate to fill the soil reservoir, use a fall irrigation or irrigate before planting. Avoid irrigations between planting and emergence. Irrigations at this time can increase blackleg, Rhizoctonia stem and stolon canker, and seed piece decay. It is best to have soil moisture high enough so that the first irrigation is not needed until plants have emerged. However, irrigations must be used if the soil becomes excessively dry, and they may also be needed to reduce wind erosion.

**Postplant irrigations**

With sprinklers, each postplant irrigation should bring the top 18 inches of soil back to field capacity; do not irrigate to a depth of more than 24 inches. The timing and amounts of postplant irrigations depend on the water-holding capacity of the upper 18 inches of soil and the rate at which the water is used by evapotranspiration. Maintaining adequate soil moisture is critical during the tuber initiation and tuber growth phases; water stress during these periods may cause tuber malformations and translucent end, especially in Russet Burbank. Dry conditions before tuber initiation discourages Verticillium wilt but favor common scab infections; be sure to know which disease is of greater importance in your area. Overly wet soils favor powdery scab infections.

Final irrigations in most growing areas should be timed to allow soil moisture to drop to about 60% of field capacity at the time of vinekill. The optimum moisture level depends on soil type, the variety, and its bruise potential. On sandy soils, higher moisture content can usually be tolerated and some varieties perform better at 70 to 80% of field capacity until harvest. This level of soil moisture encourages proper development of the tuber skin and decreases the chance that tubers will be infected.
During harvest by early blight, late blight, or soft rot pathogens. However, if soil moisture falls below 50% during vinekill, stem end browning may result. In hot growing areas, light irrigations may be continued until harvest to keep soil temperatures down. Excess irrigation at this time may reduce oxygen levels in the soil and cause tuber rot or black heart.

**Irrigation scheduling**

Timing of irrigations during the growing season can be based on various measures of soil moisture together with a water budget, which can be based on evapotranspiration or pan evaporation data. A combination of methods is usually best, and disease potential must be considered.

Always check soil moisture before applying water and estimate how much available water remains in the crop rooting depth. Use a soil tube or shovel to take soil from the rooting zone at several points in each field. The feel and appearance of the soil, as outlined in the table below can be used as a guide for judging the depletion level in soil taken from the root zone.

<table>
<thead>
<tr>
<th>Judging Depletion of Soil Water by Feel and Appearance.</th>
<th>Inches of water needed</th>
<th>Medium-textured soils</th>
<th>Inches of water needed</th>
<th>Fine-textured soils</th>
<th>Inches of water needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse-textured soils</td>
<td>0.0</td>
<td>Soil dark, feels smooth, and ribbons out between fingers; leaves wet outline on hand.</td>
<td>0.0</td>
<td>Soil dark, may feel sticky, stains hand; ribbons easily when squeezed and forms a good ball.</td>
<td>0.0</td>
</tr>
<tr>
<td>Soil looks and feels moist, forms a cast or ball, and stains hand.</td>
<td>0.3</td>
<td>Soil dark, feels slick, stains hand; works easily and forms ball or cast.</td>
<td>0.5</td>
<td>Soil dark, feels slick, stains hand; ribbons easily and forms a good ball.</td>
<td>0.7</td>
</tr>
<tr>
<td>Soil dark, stains hand slightly; forms a weak ball when squeezed.</td>
<td>0.6</td>
<td>Soil crumbly but may form a weak cast when squeezed.</td>
<td>1.0</td>
<td>Soil crumbly but pliable; forms cast or ball, will ribbon; stains hand slightly.</td>
<td>1.4</td>
</tr>
<tr>
<td>Soil forms a fragile cast when squeezed.</td>
<td>1.0</td>
<td>Soil crumbly, powdery; barely keeps shape when squeezed.</td>
<td>1.5</td>
<td>Soil hard, firm, cracked; too stiff to work or ribbon.</td>
<td>2.0</td>
</tr>
</tbody>
</table>

1Amount needed to restore 1 foot of soil depth to field capacity when soil is in the condition indicated.

Water needs usually vary from one part of a field to another, especially if the field includes different soil types or slopes. Plants in a sandy streak or where root growth has been restricted show stress sooner than the rest of the crop. Watch these weak areas to gain advance notice of when irrigation is needed for the rest of the field. However, schedule irrigations according to the need shown by most of the crop.

Instruments are available that measure the moisture content of the soil. Tensiometers and neutron probes are frequently used for monitoring soil moisture. To obtain reliable readings, you must install these instruments in areas representative of the field.
including spots where water stress occurs more readily. Aerial infrared photography can help identify areas of different moisture stress within fields. At each site install one soil moisture probe at the rooting depth of the current growth stage and a second probe 18 to 24 inches deep. Follow the recommendations of irrigation experts in using soil probes for irrigation scheduling.

A convenient way to monitor soil moisture indirectly is to use a water budget to estimate how much water the crop uses from day to day under prevailing weather conditions. After soil has drained to field capacity, further loss of soil water occurs mainly through evaporation from the soil surface or transpiration from leaves. The combination of evaporation and transpiration is called evapotranspiration (ET). If you know how much available water is in the crop rooting depth at field capacity and how much water is lost through ET each day, you can estimate the amount of available water remaining at any time by adding up the daily ET values. Newspapers and radio and television stations in some areas report ET figures for major crops, including potatoes. Water use information for most potato-growing areas is available on the internet from CIMIS for California locations (cimis.water.ca.gov). Information is also available from private consulting firms; check with local authorities regarding sources of information for your area.

You can also use daily pan evaporation and a water use curve for the crop to develop your own ET figures. To use this curve, determine the water use coefficient for the current stage of potato growth, for example, a value of 0.45 during tuber initiation. Multiply the daily pan evaporation by this figure to get actual crop water use. Pan evaporation can be obtained from local weather stations as well as the CIMIS Web site.

Water budgets provide estimates of crop water use. However, actual water use is affected by cultivar, disease, weeds, insects, physical characteristics of individual fields, and management factors. Use a direct measurement of soil moisture to make the final decision about when to irrigate.

A good irrigation program follows these basic guidelines.

- Start with soil at field capacity and avoid irrigation between planting and emergence.
- Monitor the soil moisture.
- Record daily ET.
- Keep records of irrigation and rainfall amounts.
- Do not irrigate deeper than 18 to 24 inches or more frequently than necessary.
- If late blight is a risk, irrigate only when foliage will dry before nightfall; begin irrigation during early morning only when foliage will dry within 6 to 8 hours; do not run solid set sprinklers longer than 6 hours, regardless of time of day. Turn off the sprinklers near the center of a pivot as much as possible.
- Avoid wet soil (soil with moisture in excess of levels recommended for the current stage of growth).
- Use irrigation systems designed to give uniform water distribution.
• Be sure to reduce irrigations, matching the decreased plant demand in late season, to avoid excess water that encourages development and spread of late blight as well as other tuber rots.

Text updated: 8/19
Seed Certification and Seed Tuber Handling

Seed certification

Many pests can be transmitted in infected seed tubers, including bacterial ring rot, blackleg, bacterial soft rot, common scab, late blight, potato viruses, powdery scab, Rhizoctonia, root-knot nematodes, silver scurf, and wilt diseases. Stem cutting and micropropagation techniques have been developed to obtain pest-free potato plants for propagation and production of certified seed tubers. Several generations of plants are grown in the field to produce certified seed tubers that will be sold to commercial growers.

Certified seed tubers are not guaranteed to be disease free. They are certified to have shown no more than certain low percentages of pest and disorder symptoms during the inspections required by a state's seed certification program. The allowable level of symptom expression for each pest or disorder is called a tolerance level, and these levels vary from state to state. A zero tolerance exists for certain pests, such as bacterial ring rot and root-knot nematode. To pass these tolerances, seed lots must be inspected at least twice in the field during the growing season and be inspected in storage or at the time of shipment. Check specific Potato Seed Certification Standards for pest tolerances enforced in California. Depending on your own situation and tolerance for particular diseases, your seed purchasing decision might involve a stricter standard.

Seed tuber handling

Store seed tubers at 38°F. To increase seed age, higher temperatures can be used. About two weeks before cutting, warm seed tubers gradually to 50° to 55°F and hold them at that temperature with a relative humidity greater than 90% and good ventilation. This reduces the amount of tissue tearing during cutting and encourages wound healing (suberization) after potatoes are cut, greatly reducing the incidence of seed piece decay after planting.

If tubers are cut when they are just beginning to sprout, a stage sometimes called "peep" or "peek" emergence is more rapid, and you can more easily choose a seed piece size that gives the number of sprouts you want. Cut seed tubers before sprouts exceed about 1/8 inch (3 mm) in length to avoid breaking them and reduce the chance of spreading disease during cutting. If sprouts are broken, the spread of mechanically transmitted viruses increases and seed pieces may develop multiple sprouts, which are weaker, and may form too many stems per hill. A seed piece size of 1.5 to 2.5 ounces is recommended for optimum performance in most areas. The larger size is recommended for cultivars that have few eyes, such as CalWhite and Russet Nugget. Seed treatments may be applied at this time to protect against certain diseases and insects (see table below). Follow good sanitation practices during cutting; clean and disinfect cutting equipment thoroughly between seed lots. Protect the cut seed from sun and wind when hauling.

Plant cut seed pieces immediately in moist soil (60 to 80% of field capacity) that is at a minimum of 45°F to accelerate emergence and wound healing after planting. If you
cannot plant cut seed immediately, hold it at 50° to 55°F with good aeration and high humidity to speed wound healing. Store cut seed only where adequate airflow can be maintained throughout the pile. Do not store cut seed in bulk trucks. Do not plant seed that is cooler than the soil, particularly early in the season.

Text updated: 8/19
Storage

A large part of the crop in the Klamath Basin is stored for fresh market or processing during winter and spring. All seed tubers are stored.

Designs for potato storage facilities can vary but have controls for temperature, humidity, and ventilation. Ventilation is essential during storage. It removes field heat, excess moisture that may condense on colder tubers, and carbon dioxide and heat produced by respiration; at the same time, it helps provide even temperature and humidity within the storage area and oxygen to support tuber respiration. Uniform airflow throughout the pile is important.

To reduce the risk of rot developing and spreading during the storage season, have wet or rotting tubers and any foreign material removed from the incoming conveyors when filling a storage unit. Don't mix "good" and "bad" lots in the same storage, and place lots with possible problems nearest the door so they can be removed without impacting other lots in the storage.

The storage period consists of four phases: post-harvest, curing, holding, and warming.

Post-harvest (pre-storage)

Treat russet type potatoes that are to be stored longer than three months where silver scurf has been confirmed.

Curing

During the first part of storage, hold tubers at a temperature of 50° to 55°F with relative humidity above 95%. These conditions favor rapid suberization of any bruises or cuts incurred during harvest and allow the skin of immature tubers to mature. Both of these processes increase the resistance of tubers to decay. Hold tubers under curing conditions for a minimum of two weeks, then lower the temperature by 0.5°F or less per day until the desired holding temperature is reached. Avoid condensation caused by bringing in warm supply air on cold tubers. If there is increased risk of decay, as with tubers injured by frost or tubers exposed to late blight or excessively wet conditions during harvest, store affected lots separately. Cool them to 50°F and dry them as quickly as possible with high flows of non-humidified air. Be careful not to over-dry the tubers because loss of tuber weight will occur.

Holding

For most of the storage time, hold tubers at the lowest temperature possible without affecting market quality. The following holding temperatures are recommended:

- chipping: 50° to 55°F; lower for cultivars resistant to cold sweetening
- French fries: 45° to 50°F; lower for cultivars resistant to cold sweetening
- fresh market: 38° to 45°F
• seed: 37° to 40°F

Maintain humidity high enough to keep tubers from drying and to avoid pressure bruising but low enough to prevent surface wetness. Some cultivars are more susceptible to pressure bruise; shallower piles may be needed to reduce the likelihood of pressure bruise. Remember that high humidity maintains pile weight, but condensation encourages disease. After proper curing, manage the humidity to prevent surface moisture on tubers. Always visit storages at least once a week to look for storage problems.

Higher temperatures and longer storage times can increase the severity of leafroll net necrosis.


**Warming**

If holding temperatures were lower than 50°F, letting tubers warm up to this temperature before removing them from storage reduces bruising. Allow the heat of respiration to warm tubers. Do not use warm air; condensation may occur on cold tubers, creating conditions that favor decay. Be sure to maintain humidity to keep tuber water content at the proper level. Tubers with lower water content are more susceptible to blackspot bruising. If excessive sugars have accumulated in tubers to be used for processing, warming above 50°F for three weeks may reduce the sugar to acceptable levels. Before cutting seed tubers, warm them at least 10 days at 50° to 55°F to increase their wound-healing ability. Warmed tubers also cut more easily with less physical damage.

Text updated: 8/19
Insects, Mites, and Other Invertebrates

Relative Toxicities of Insecticides and Miticides Used in Potatoes to Natural Enemies and Honey Bees

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Mode of action¹</th>
<th>Selectivity² (affected groups)</th>
<th>Predatory mites³</th>
<th>General predators⁴</th>
<th>Parasites⁵/Honey bees⁵</th>
<th>Duration of impact to natural enemies⁶</th>
</tr>
</thead>
<tbody>
<tr>
<td>abamectin (Agri-Mec)</td>
<td>6</td>
<td>moderate (psyllids)</td>
<td>M</td>
<td>L</td>
<td>M/H</td>
<td>moderate to affected insects short</td>
</tr>
<tr>
<td>carbaryl, bait (Sevin Bait)</td>
<td>1A</td>
<td>narrow (cutworms)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>III</td>
</tr>
<tr>
<td>carbaryl (Sevin)</td>
<td>1A</td>
<td>narrow (cutworms)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>III</td>
</tr>
<tr>
<td>cyfluthrin (Baythroid, Leverage)</td>
<td>3A</td>
<td>broad (insects)</td>
<td>M/H</td>
<td>M/H</td>
<td>H</td>
<td>I</td>
</tr>
<tr>
<td>dinofuran (Venom)</td>
<td>4A</td>
<td>narrow (sucking and chewing insects)</td>
<td>L</td>
<td>—</td>
<td>L</td>
<td>I</td>
</tr>
<tr>
<td>esfenvalerate (Asana)</td>
<td>3A</td>
<td>broad (insects)</td>
<td>H</td>
<td>M</td>
<td>H</td>
<td>I</td>
</tr>
<tr>
<td>ethoprop (Mocap)</td>
<td>1B</td>
<td>narrow (soil insects)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>II short</td>
</tr>
<tr>
<td>imidacloprid (Admire Pro)</td>
<td>4A</td>
<td>narrow (sucking and chewing insects)</td>
<td>—</td>
<td>L</td>
<td>—</td>
<td>I</td>
</tr>
<tr>
<td>indoxacarb (Avault)</td>
<td>22A</td>
<td>narrow (caterpillars)</td>
<td>—</td>
<td>L</td>
<td>L</td>
<td>I</td>
</tr>
<tr>
<td>lambda-cyhalothrin (Warrior)</td>
<td>3A</td>
<td>broad (plant bugs, beetles, caterpillars, psyllids)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
</tr>
<tr>
<td>methomyl (Lannate)</td>
<td>1A</td>
<td>broad (insects)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
</tr>
<tr>
<td>novaluron (Rimon)</td>
<td>15</td>
<td>narrow (caterpillars)</td>
<td>L</td>
<td>L</td>
<td>—</td>
<td>I short</td>
</tr>
<tr>
<td>pymetrozine (Fulfill)</td>
<td>9B</td>
<td>narrow (sucking insects)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>II short</td>
</tr>
<tr>
<td>spinetoram (Radiant)</td>
<td>5</td>
<td>narrow (aphids, caterpillars, psyllids, whiteflies)</td>
<td>L/H</td>
<td>M⁷</td>
<td>L/M</td>
<td>II moderate⁹</td>
</tr>
<tr>
<td>spinosad (Entrust, Success)</td>
<td>5</td>
<td>narrow (caterpillars, psyllids)</td>
<td>L</td>
<td>M⁷</td>
<td>L/M</td>
<td>II moderate⁷</td>
</tr>
<tr>
<td>spiromesifen (Oberon SC)</td>
<td>23</td>
<td>narrow (psyllids, whiteflies)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>II —</td>
</tr>
<tr>
<td>spirotetramat (Movento)</td>
<td>23</td>
<td>narrow (sucking insects)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>II short</td>
</tr>
<tr>
<td>thiamethoxam (Platinum, Cruiser)</td>
<td>4A</td>
<td>narrow (sucking insects, wireworms)</td>
<td>—</td>
<td>—</td>
<td>M</td>
<td>I moderate</td>
</tr>
</tbody>
</table>

¹Rotate 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 for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee).

²Selectivity: broad means it affects most groups of insects and mites; narrow means it affects only a few specific groups.

H = high   M = moderate   L = low   — = no information
Generally, toxicities are to western predatory mite, *Galendromus occidentalis*. Where differences have been measured in toxicity of the pesticide-resistant strain versus the native strain, these are listed as pesticide-resistant strain/native strain.

Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific insecticide depends on factors including the application rate, environmental conditions, and life stage and species of parasite or predator.

Ratings are as follows: I—Do not apply or allow to drift to plants that are flowering including weeds. Do not allow pesticide to contaminate water accessible to bees including puddles. II—Do not apply or allow to drift to plants that are flowering including weeds, except when the application is made between sunset and midnight if allowed by the label and regulations. Do not allow pesticide to contaminate water accessible to bees including puddles. III—No bee precaution, except when required by the label or regulations. For more information, see [Bee Precaution Pesticide Ratings](#).

Duration: *short* means hours to days; *moderate* means days to 2 weeks; and *long* means many weeks or months.

Toxic against some natural enemies (predatory thrips, syrphid fly and lacewing larvae, beetles) when sprayed and up to 5 to 7 days after, especially for syrphid fly larvae.

May cause an increase in spider mites

Residual is moderate if solution is between pH of 7 to 8.

Acknowledgments: This table was compiled based on research data and experience of University of California scientists who work on a variety of crops and contribute to the Pest Management Guideline database, and from Flint, M.L. and S.H. Dreistadt. 1998. *Natural Enemies Handbook: An Illustrated Guide to Biological Pest Control*, ANR Publication 3386.

Text updated: 04/19
Aphids

Green peach aphid: *Myzus persicae*

Potato aphid: * Macrosiphum euphorbiae*

**Description of the Pest**

The two most common aphids on potatoes are the green peach aphid and the potato aphid. Both species occur statewide. The green peach aphid is usually the most common and abundant species; infestations typically begin on the bottom most leaves of the plant. Potato aphid infestations are generally scattered over the plant.

**Winged adults** of the green peach aphid are pale or bright green and black, with a large, dusky blotch on the dorsum of the abdomen. The immature forms are yellow, pinkish, or pale green. The mature, wingless forms are pale or bright green.

**Pink and green forms** of the potato aphid are found in potatoes. This aphid is larger than the green peach aphid with longer cornicles and legs. Potato aphid colonies are made up of adults with offspring closely clustered together.

The two species can be most reliably distinguished by looking at the tubercles between the base of the antennae. The tubercles of the potato aphid slope outward and those of the green peach aphid converge.

**Damage**

Aphids damage potatoes primarily by spreading plant diseases. Occasionally, aphids become so abundant that their feeding weakens the plants. Potato leafroll virus is spread by both aphids, but green peach aphid is by far the more effective vector. Early season leafroll infection stunts the plant. Plants grown from infected seed potatoes will not produce marketable potatoes. An infected Russet Burbank potato often has phloem net necrosis, a brown discoloration inside the potato that reduces quality. The brown discoloration is most intense at the stem end but may extend well into the tuber. White Rose and red-skinned varieties do not develop net necrosis. Other viruses spread by aphids include cucumber mosaic and alfalfa mosaic (calico).

**Management**

Management of green peach aphid and potato aphid involves an integrated program of reducing overwintering populations, controlling weeds in and around the field, and the use of foliar sprays. Monitor to schedule spray treatments.

**Biological Control**
Many parasites and predators attack aphids. Among the more common predators are lady beetles and their larvae, lacewing larvae, and syrphid fly larvae. Populations of green peach aphids are reduced in winter by a parasitic fungus, Entomophthora aphidis. Most materials available for aphid control are highly disruptive of natural enemy populations.

**Cultural Control**

Weeds along ditch banks, roads, in farm yards, and other noncultivated areas contribute directly to the aphid problem. *Malva* is an important overwintering host in the Central Valley and southern potato production areas. In northern areas, tumble mustard (*Sisymbrium altissimum*), penny cress (*Thlaspi arvense*), and other mustards (*Brassica* spp.) serve as early season host plants where aphid populations increase before spreading to other host plants, including commercial potatoes.

It is also important to control nightshades and volunteer potatoes because these plants are reservoirs for potato leafroll virus. Rogue infected potato plants to reduce the incidence of infection and spread of the disease within a field. For maximum effectiveness remove the diseased plant, the three plants on each side of the diseased plant in the same row, and the three closest plants in adjacent rows. Rogueing is most important in seed fields.

Plant disease-free seed to reduce the incidence of potato leafroll virus.

**Organically Acceptable Methods**

Use biological and cultural controls on organically certified potatoes.

**Monitoring and Treatment Decisions**

In Northern California, migration of winged green peach aphids from weed hosts usually begins in early June. Inspect fields weekly. Aphids are first found on those plants along the edge of the field toward the prevailing wind, usually the north or west edge of the field. If aphids are found on the edge, sample 100 leaves, taking 50 bottom leaves on a line from one corner of the field to the center of the field and another 50 bottom leaves on a line to the other corner of the field (example: 50 leaves from northwest corner to center; 50 leaves from center to northeast corner). Record your results (example form—PDF).

In other areas of California, growers should make general observations to determine if aphids are present. Sample weekly throughout the growing season and record your results (example form—PDF). Heavy populations normally occur late in the spring.

In northern areas, apply foliar insecticides when 5% of the leaves are infested. There are no established thresholds in other parts of California because aphids rarely cause economic damage to cultivars grown for commercial production in these areas.
In seed potato production, a preventive program using insecticide applications at 2 to 3 week intervals may be necessary.

<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. **IMIDACLOPRID**  
(Admire Pro)  
5.7–8.7 fl oz  
12  
NA  
MODE OF ACTION GROUP NUMBER‡: 4A  
COMMENTS: Apply to soil following label directions. Do not exceed 8.7 fl oz/acre per crop.

B. **SPIROTETRAMAT**  
(Movento)  
4.0–5.0 fl oz  
24  
7  
MODE OF ACTION GROUP NUMBER‡: 23  
COMMENTS: Apply early at the first sign of aphid presence. Do not exceed two applications per crop or make applications at less than 7-day intervals.

C. **LAMBDA-CYHALOTHIRN**  
(Warrior II with Zeon)  
1.28–1.92 fl oz  
24  
7  
MODE OF ACTION GROUP NUMBER‡: 3A

** See label for dilution rates.
‡ 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 for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee).

## Important Links

- [Potato aphid monitoring, Northern California](#) (PDF)
- [Surveying foliage pests form](#) (PDF)

Text updated: 4/19  
Treatment table updated: 4/19
Beet Leafhopper

*Circulifer tenellus*

Description of the Pest

Most leafhoppers are minor problems on potatoes in California with the exception of the beet leafhopper. Adults are small, pale green or mottled brown, somewhat wedge shaped, and about 0.12 inch (3 mm) long. Nymphs are whitish to pale green and move rapidly when disturbed. Both adults and nymphs are found on the underside of the leaves.

Damage

Leafhoppers feed by sucking sap from the plant causing a white to yellowish stippling of the leaves, browning of the leaves, or yellowing of lower leaves depending upon the species involved. The beet leafhopper is responsible for transmitting the curly top virus.

Management

Treatment is occasionally necessary in California; however, treatment thresholds have not been established. Keep weeds controlled in and around the field, especially with late spring plantings in the southern San Joaquin Valley. The insecticides suggested for control of aphids and flea beetles will control leafhopper populations.

Text updated: 4/19
Cutworms

Black cutworm: *Agrotis ipsilon*

Variegated cutworm: *Peridroma saucia*

**Description of the Pest**

The most common species encountered are the black cutworm and the variegated cutworm. The adults are dull-colored brown to grayish moths. The larvae are usually earthen-colored with various stripes or spotted color patterns. They are smooth-bodied worms that may be 2 inches in length when mature. Many species curl into a C-shape when disturbed.

**Damage**

Cutworms may cut off the stems of young plants during stand establishment. Later in the season they feed on foliage. Tubers that are exposed on the soil, or by cracks, or are set very shallow may be damaged. Cutworm damage to tubers appears as a gouged out cavity.

**Management**

Cutworms are not an annual problem, nor are they a problem in every field. Weed control in and around the field before planting will reduce cutworm problems through reduction of early season host plants. Treatment thresholds have not been established. Monitor the field (PDF) to detect cut plants and foliar feeding early in the season. Later in the season, inspect plants for foliage damage. Also, shake the plants over a beating cloth placed in the row and inspect the beds and furrows for larvae, and inspect shallow set and exposed tubers for damage. Keep records of your monitoring results (example form)—PDF). Treatment is necessary where worms are abundant and before the tubers are damaged.

<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. CARBARYL</strong> (Sevin 5% Bait)</td>
<td>20–40 lb</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td><strong>MODE OF ACTION GROUP NUMBER‡</strong>: 1A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. METHOMYL</strong> (Lannate LV)</td>
<td>1.5 pt</td>
<td>48</td>
<td>6</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.
MODE OF ACTION GROUP NUMBER: 1A

COMMENTS: Not recommended in fields where potato psyllids are present because it promotes increases in their numbers.

C. LAMBDACYHALOTHRIN
(Warrior II with Zeon) 0.96–1.60 fl oz
MODE OF ACTION GROUP NUMBER: 3A

** See label for dilution rates.
‡ 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 for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee).

Important Links

- [Surveying foliage pests form](#) (PDF)

Text updated: 4/19
Treatment table updated: 4/19
Flea Beetles

*Epitrix* spp.

**Description of the Pest**

Flea beetles are minor pests of potatoes in California, except in the Klamath Basin production area where they are becoming a substantial pest. The **adults** are small, 0.06 to 0.1 inch (1.5 to 2.5 mm) in length, metallic greenish brown to black in color, and tend to jump like fleas when disturbed. The larvae live in the soil, are slender, whitish, and about 0.25 inch (6 mm) long when mature.

Adult flea beetles overwinter in weeds or debris outside the field. In spring they feed on weeds until potato plants emerge, then fly into potato fields and feed on foliage.

**Damage**

The beetles feed on leaves and stems resulting in many **small holes** in the leaves. This damage is seldom extensive enough to be of concern but may indicate future damage to the tubers. Watch for foliage damage when monitoring fields for this and other foliage-feeding pests, and keep records of your results (example form—PDF). Most damage is caused by the larvae, which hatch from eggs scattered by adult females in the soil around potato plants. The larvae feed on roots, underground stems, and tubers. Larval feeding on tubers gives them a pimpled surface with small brown tunnels extending 0.06 to 0.25 inch (1.5 to 6 mm) into the tuber. When damage is extensive, the potatoes are unsuitable for processing.

**Management**

Systemic insecticides and foliar sprays applied for green peach aphid usually keep flea beetles below economically damaging levels. Even in areas where these treatments are not used, flea beetle infestations are sporadic and special controls are rarely necessary. Flea beetle damage often is not noticed until harvest, when it is too late for control measures.

<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. <strong>DINOTEFURAN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Venom, soil application)</td>
<td>6.5–7.5 oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>(Venom, foliar application)</td>
<td>1–1.5 oz</td>
<td>12</td>
<td>7</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> Do not apply more than 0.754 lb/acre per season. If an application of imidacloprid (Admire Pro) was made at planting, choose another treatment material with a different mode of action Group number to help prevent the development of neonicotinoid resistance.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. IMIDACLOPRID</strong> (Admire Pro)</td>
<td>5.7–8.7 fl oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Apply to soil following label directions. Do not exceed 8.7 fl oz/acre per crop. Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. LAMBDA-CYHALOTHРИN</strong> (Warrior II with Zeon)</td>
<td>1.28–1.92 fl oz</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D. CARBARYL</strong>* (Sevin 4F)</td>
<td>0.5–1.0 qt</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 1A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Not recommended in fields where potato psyllids are present because it promotes increases in their numbers.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** See label for dilution rates.
‡ 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 for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee).

**Important Links**

- [Surveying foliage pests form](#) (PDF)

Text updated: 4/19
Treatment table updated: 4/19
Potato Psyllid

*Bactericera (=Paratrioza) cockerelli*

**Description of the Pest**

Potato psyllids look like small cicadas, about 0.08 inch (2 mm) long. They are related to aphids and leafhoppers. The **adult** has clear wings that rest rooflike over the body. Although predominantly black, the potato psyllid possesses white markings. The first abdominal segment shows a broad white band, the last segment has an inverted white "V". Psyllids jump quite readily when disturbed.

The football-shaped **eggs** are extremely small, slightly larger than leaf hairs, and on a short stalk. Although they can be found all over the leaves, they are easiest to see on the underside of the leaf along the edge and in the upper plant canopy. A 10X hand lens is required to see them.

Psyllid **nymphs** look like immature soft scale or whiteflies. Unlike whiteflies, when disturbed, they move quite readily. They are flat and green with a fringe of short spines around the edge. The immatures go through five instars in as little as 13 days depending on temperature.

Psyllids used to be an occasional problem on potatoes, peppers, tomatoes, and other solanaceous crops in California in certain years when they would migrate into the state from Mexico. In recent years however, a more invasive form of the species has been found in California that has the ability to overwinter. Potato psyllid now occurs on a yearly basis and has become a chronic problem for potatoes.

**Damage**

Potato psyllid can cause the damage to the crop in more than one way. Psyllids transmit a bacterium *Candidatus Liberibacter solanacearum* (LSO) which is responsible for a condition known as zebra chip. This disease severally affects potato plant growth and yield. The bacterium causes sugars to accumulate in areas of the tuber instead of starch. These areas turn black and more pronounced when infected tubers are processed into fried chips or fries, creating a characteristic pattern that gives rise to the name "zebra chip" and makes potato chips and French fries unmarketable. Whole crops might be rejected, leading to abandonment of entire fields.

While zebra chip is the characteristic symptom of an infection with the LSO bacterium, other above ground symptoms can include aerial tuber formation, plant stunting, and chlorosis resembling psyllid yellows diseases. Infection is irreversible, and symptoms continue to increase in severity over the time. Potato plants affected by the disease early in the development can die in less than 3 weeks. Plants exposed to LSO-infected psyllids less than three weeks before harvest usually produce tubers without zebra chip symptoms. It is not known how extensively or how rapidly symptomless but infected tubers develop zebra chips symptoms in storage.
Feeding by potato psyllid nymphs, and sometimes adults, can also result in psyllid yellows. Symptoms include an upward curling of leaflets nearest the stem on the top part of the plant. As the disease establishes itself, this symptom becomes more evident. Plant yellowing is the most common symptom. The yellowing (in some varieties, purpling) is initially found on the leaf edges. Severe symptoms include overall yellowing with enlarged nodes, development of clusters of small leaves in the axillary buds that appear rosetted. Internodes are shortened, and the plant eventually is dwarfed and appears pyramid shaped. Below-ground symptoms include setting of excessive numbers of tiny misshaped potato tubers, production of chain tubers, and early breaking of tuber dormancy. If the immature psyllids are removed from the plant, the progression of the disease will stop. As few as three or four nymphs per plant can produce symptoms but more are needed for severe symptoms. Psyllid yellows is suspected to be caused by a currently unidentified toxin that immature psyllids produce when they feed.

Third, feeding by potato psyllids results in substantial honeydew accumulation and can lead to fungal infestations.

**Management**

**Biological control**
While various predators and parasites including spiders, lacewings, and the parasitoid *Tamarixia ribeum*, may attack psyllids, most parasites attack too late in the psyllid life cycle to stop crop loss. However, conservation of existing natural enemies, especially predators, provides additional control and therefore it is critical to use pesticides that maximize the effects on the psyllids while minimizing the effects on natural enemies.

**Organically Acceptable Methods**
Use sprays of the Entrust formulation of spinosad on an organically certified crop.

**Monitoring and treatment decisions**
It is increasingly important that management of the potato psyllid take an area-wide approach that considers all potential host crops, particularly tomatoes. Psyllid movement between crops, timing of crop planting, and which crops are adjacent to others all need to be considered.

Use yellow sticky traps placed at the field margins near the tops of plants early in the season to detect the movement of the first potato psyllids invading the crop. If psyllids are caught in the traps, examine foliage of potato plants. Because potatoes are highly susceptible to the zebra chip pathogen, sampling must consider all life-stages. Nymphs are most easily identified and occur in greater numbers than adults in California. Plants should be sampled from multiple locations in the field. However, the field margins are a good place to start sampling because these insects colonize the edges of fields first. Very early in the season, examine whole plants; later concentrate on leaves in the top two-thirds of the plant. Nymphs and eggs are typically located on the underside of leaves. Sample and examine with field hand lens 12 to 50 plants, with 20 being optimal. Inverted lead blowers can be used for adult sampling. Keep records of your sampling results ([example form](#PDF)).
In southern states (e.g., Texas), where potato psyllids are known to affect potato plants since plant emergence, it is recommended that potato and tomato fields in areas where the psyllid is known to occur should be treated at planting with neonicotinoid insecticides, such as imidacloprid. Be aware that at some locations potato psyllid appears to have developed resistance to imidacloprid. There are no reports of resistance to imidacloprid in California or the Pacific Northwest. In the Pacific Northwest insecticides at planting are not recommended for psyllids control since psyllids arrive in potato fields late June, early July.

Currently, there is no economic threshold for psyllid in any North American crop, including potatoes. Most growers treat immediately when first potato psyllids are detected in the field due to the risk of zebra chip. Do not let a generation complete its life cycle in the field and reproduce, as the LSO pathogen will spread rapidly with the help of its psyllid vector. Rotate insecticides with different mode of action to minimize resistance development.

If psyllids are present in the field, it is very important not to use carbamates (e.g., Sevin-foliar applications, Lannate, Vydate) for the control of other pests as these materials actually promote the increase of psyllid numbers.

<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>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>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**AT PLANTING**

A. **IMIDACLOPRID**
   (Admire Pro)
   MODE-OF-ACTION GROUP NUMBER: 4A
   COMMENTS: Apply at planting as a side dress or through drip irrigation. Does not harm most beneficials. To reduce the potential for the development of resistance, avoid the use of neonicotinoids both as a soil and a foliar application on the same crop.

<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>IMIDACLOPRID</td>
<td>5.7–8.7 fl oz</td>
<td>12</td>
<td>NA</td>
</tr>
</tbody>
</table>

B. **THIAMETHOXAM**
   (Platinum)
   MODE-OF-ACTION GROUP NUMBER: 4A
   COMMENTS: For in-furrow applications. Make only one application per season.

<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>THIAMETHOXAM</td>
<td>5.0–8.0 fl oz</td>
<td>12</td>
<td>NA</td>
</tr>
</tbody>
</table>

**GROWING SEASON**

A. **ABAMECTIN**
   (Agri-Mek SC)*
   MODE-OF-ACTION GROUP NUMBER: 6
   COMMENTS: An insect growth regulator that is not harmful to most beneficials.

<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>ABAMECTIN</td>
<td>1.75–3.5 fl oz</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

B. **SPIROTETRAMAT**
   (Movento)
   MODE-OF-ACTION GROUP NUMBER: 23
   COMMENTS: Apply early at the first sign of psyllid presence. Do not exceed two applications per crop or make applications at less than 7-day intervals. Applications should be made back to back since this insecticide has limited movement in the plant.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre**</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPIROTETRAMAT</td>
<td>4–5 fl oz</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>Common name (Example trade name)</td>
<td>Amount per acre**</td>
<td>REI‡ (hours)</td>
<td>PHI‡ (days)</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>C. LAMBDA-CYHALOTHIRIN (Warrior II with Zeon)</td>
<td>1.28–1.92 fl oz</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>D. THIAMETHOXAM (Platinum)</td>
<td>5.0–8.0 fl oz</td>
<td>12</td>
<td>NA</td>
</tr>
<tr>
<td>E. SPIROMESIFEN (Oberon 2SC)</td>
<td>8–16 fl oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>F. SPINETORAM (Radiant)</td>
<td>4–8 fl oz</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>G. PYMETROZINE (Fulfill)</td>
<td>5.5 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>H. SPINOSAD (Entrust)# (Success)</td>
<td>1.5–3 oz</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>(Entrust)#</td>
<td>4.5–10 oz</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>I. IMIDACLOPRID/CYFLUTHRIN (Leverage)</td>
<td>2.8 fl oz</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>

COMMENTS:
- Apply early at the first sign of psyllid presence. Nymphal stage. Do not exceed two applications per crop or make applications at less than 7-day intervals.
- Do not make more than two consecutive applications of group 5 insecticides. Do not exceed 32 fl oz/acre per year.
- For suppression only.
- Do not exceed 21 fl oz of Success or 6.5 oz of Entrust/acre per crop.
- Leverage should be used sparingly or as a last resort to minimize the potential for resistance to neonicotinoids.

** See label for dilution rates.
‡ 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.
# Acceptable for use on organically certified produce.
NA Not applicable

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 for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee).

Important Links
- [Surveying foliage pests form](#) (PDF).
Text updated: 4/19
Treatment table updated: 4/19
Potato Tuberworm

*Phthorimaea operculella*

**Description of the Pest**

The adult is a small moth with a wing expanse of 0.5 inch (1.2 cm). When at rest, the wings are held close to the body giving the moth a slender appearance. The general color is gray with darker gray-brown or black markings. The eggs are very small, oval, and range from white to yellowish. Full grown larvae are caterpillars that vary in color from whitish, dirty white to grayish, pink, or greenish when feeding in stems or leaves. They are 0.4 inch (1 cm) in length with a brown head and dark prothoracic shield.

**Damage**

The potato tuberworm is not a problem in the northern potato-producing areas of California. In other areas, it can be a minor to serious pest depending upon the area and year. Though severe damage to young plants is rare, high numbers of worms in very young plants may result in stand reduction or stunted plants as a result of leaf and stem mining. The typical damage results from larvae mining in the tubers. Small larvae usually enter the tuber at the eyes. Small deposits of frass can be seen in webbing around an eye where a larva has begun to tunnel. Frequently, the larvae feed just below the surface of the potato leaving a dark tunnel. Occasionally they bore deep into the tuber. In either case, the tunnel is filled with excrement and can be described as a dirty tunnel compared to the clean tunnels made by wireworms or other soil-inhabiting insects. Tubers that are exposed as a result of shallow setting or cracks in the soil are most frequently infested. The longer the tubers remain in the ground after vine kill, the more damage that can be expected. Tuberworms do not tunnel through stems and roots into the tubers.

**Management**

Any practice that reduces the exposure of tubers to egg-laying female moths will reduce tuberworm damage. Sanitation is also important for preventing infestations. Moths can be monitored with pheromone traps to determine the need to treat.

**Cultural Control**

Shallow setting varieties are generally more susceptible than varieties that set tubers deep. Prevention of soil cracking in the beds will reduce tuberworm damage. Cracking of the soil is less severe under sprinkler irrigation than with furrow irrigation. Thus, furrow-irrigated fields have a much greater potential to become infested than sprinkler-irrigated fields. Prompt, thorough harvest and sanitation are also essential. Destroy cull piles and volunteer potatoes. Piles of cull potatoes provide a year-round breeding site for tuberworm. Volunteer plants provide a site for early season increase of the tuberworm numbers.
Organically Acceptable Methods

Use cultural control and sprays of the Entrust formulation of spinosad are on an organically certified potatoes.

Monitoring and Treatment Decisions

Watch for damage during routine field monitoring and record your results (example form—PDF).

Pheromone traps can detect potato tuberworm moth activity and aid in the timing of insecticide applications for control. One option is to use water pan traps fixed with a protective lid from which the pheromone-laden bait is suspended. Place the traps on the top of the bed, one trap in each corner of the field, but well into the field. Check and service the traps at least once a week; record sampling results (example form—PDF). Fill pans with soapy water; the soap helps break the surface tension of the water, which increases trap efficiency. Another option is to place the pheromone in a sticky trap. The advantages of sticky traps are that they do not dry out like water pan traps, but they can become dusty and no longer catch moths.

Treatment levels are not established for all production areas, but the following levels of moths per trap per night (M/T/N) are guidelines. Kern County: The threshold level is 15 to 20 M/T/N or a cumulative average of 10 M/T/N. Once a treatment has been made, base additional treatments on the 15 to 20 M/T/N threshold rather than the season average. If moths do not reach threshold levels before vine kill, do not treat. Insecticides applied at vine kill do not reduce tuberworm damage.

Insecticide treatments of pyrethroids, carbamates, or organophosphates are aimed primarily at killing adults. Applications are best if made in the evening when moths are active. These insecticides do not directly reduce larval populations of tuberworm, thus repeat applications are often needed. Three larvicides are also registered for use on potatoes. Indoxacarb is the most widely used because of its translaminar activity, which allows greater contact with larvae that are within the leaf. Novaluron and spinosad can also control larvae, but only if the worm feeds on the pesticide before entering the leaf, which can be difficult to achieve late in the season when eggs are typically on the undersides of leaves and applications are made at low volume by air.

When moths are present, tubers that are exposed either through soil cracks or erosion are likely to become infested even though insecticides are applied. This is especially true if tubers remain in the soil for a prolonged period after maturity.

<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>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>
<td></td>
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<td></td>
</tr>
<tr>
<td>Common name (Example trade name)</td>
<td>Amount per acre**</td>
<td>REI‡ (hours)</td>
<td>PHI‡ (days)</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------</td>
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<td>-------------</td>
</tr>
<tr>
<td>A. INDIXACARB (Avaunt)</td>
<td>3.5–6 oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. LAMBDA-CYHALOTHRIN (Warrior II with Zeon)</td>
<td>1.28–1.92 fl oz</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. ESFENVALERATE (Asana XL)</td>
<td>5.8 oz</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: Very destructive of aphid parasites. Do not exceed 0.35 lb a.i./acre per season.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. CYFLUTHRIN (Baythroid XL)</td>
<td>1.6–2.8 fl oz</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Very destructive of aphid parasites.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. METHOMYL* (Lannate LV)</td>
<td>1.5–3 pt</td>
<td>48</td>
<td>6</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 1A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Not recommended in fields where potato psyllids are present because it promotes increase of their numbers.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. NOVALURON (Rimon 0.83EC)</td>
<td>9–12 fl oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. SPINOSAD (Entrust)#</td>
<td>1.5–3 oz</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>(Success)</td>
<td>4.5–6 fl oz</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not exceed 21 fl oz of Success or 6.5 oz of Entrust/acre per crop.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**See label for dilution rates.  
‡ 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 for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee)  
# Acceptable for use on organically certified produce.

## Important Links

- [Monitoring potato tuberworm adults form](#) (PDF)  
- [Surveying for foliage pests](#) (PDF)  

Text updated: 4/19  
Treatment table updated: 4/19
Sweetpotato Whitefly (Silverleaf Whitefly)

*Bemisia tabaci* MEAM1 (formerly *B biotype*)

**Description of the Pest**

The most common species of whitefly infesting potato is the sweetpotato whitefly. The *adults* are tiny (0.06 inch, 1.5 mm long), yellowish insects with white wings. Sweetpotato whiteflies hold their wings somewhat vertically tilted, or rooflike, over the body and the wings do not meet over the back but have a small space separating them. Other species of whitefly have been observed in potatoes but their populations tend to be localized within the field and do not cause damage. Populations of sweetpotato whitefly can be found relatively uniformly throughout the field in fall plantings.

Whiteflies are found mostly on the undersides of leaves. They fly readily when plants are disturbed. The tiny, oval eggs hatch into a first larval stage that has legs and antennae and is mobile. Both legs and antennae are lost after the first molt and subsequent stages remain fixed to the leaf surface. The last nymphal stage, often called the "pupa" or the red-eye nymph, is the stage that is easiest to identify. Mature nymphs of sweetpotato whitefly are oval, whitish, soft, and have few to no long waxy filaments. In contrast, *greenhouse whitefly*, *Trialeurodes vaporariorum*, has many long waxy filaments and the edge of the body is somewhat vertical where it contacts the leaf surface.

**Damage**

Sweetpotato whitefly damages leaves by feeding, which causes leaves to yellow and curl, and by the production of honeydew, which causes leaves to appear shiny or blackened (from sooty mold growing on the honeydew). Damage is similar to that caused by aphid feeding: they debilitate the plants. Whiteflies cause the most damage to winter-harvested potatoes in the southern San Joaquin Valley. Fields near defoliated cotton can be severely infested.

**Management**

Whitefly populations are often held in check by beneficial insects. If populations do reach high levels, it may be necessary to apply insecticide in fall.

**Biological Control**

Several wasps, including species in the *Encarsia* and *Eretmocerus* spp., parasitize whiteflies. Whitefly nymphs are also preyed upon by *bigeyed bugs*, *lacewing larvae*, and *lady beetles*. Sweetpotato whitefly is an introduced pest that has escaped its natural enemies. Some indigenous native parasites and predators do attack it, but do not keep it below damaging numbers. The lady beetle *Delphastus pusillus* is being introduced into southern California to assist in biological control.
Cultural Control

When possible, plant potatoes at least one-half mile upwind from key sweetpotato whitefly hosts such as melons, cole crops, and cotton. Maintain good sanitation in areas of winter/spring host crops and weeds by destroying and removing all crop residues as soon as possible. Control weeds in noncrop areas including hedge rows and fallow fields and harvest alfalfa on as short a schedule as possible. In addition, allow the maximum time between whitefly host crops and produce vegetables and melons in the shortest season possible.

Organically Acceptable Methods

Use biological and cultural controls on an organically certified potato.

Monitoring and Treatment Decisions

Routinely check field margins for whiteflies; these areas are usually infested first. Record your results (example form—PDF). Be especially alert for rapid increase of whitefly numbers when nearby host crops are in decline. During these critical periods, check fields twice weekly. If beneficials are present, allow them an opportunity to control light whitefly infestations. If higher populations are present at the field margins than the field centers, then apply insecticide only the field margins. This approach will reduce treatment costs and help preserve beneficials in the field. Treatment thresholds have not been determined for sweetpotato whitefly in potato, but potatoes can take large populations of whitefly before treatment is necessary. If populations reach high levels in fall, a treatment may be warranted.

<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. DINITROFURAN
   (Venom, soil application) 6.5–7.5 oz 12 NA
   (Venom, foliar application) 1–1.5 oz 12 7
   MODE OF ACTION GROUP NUMBER¹: 4A
   COMMENTS: Do not apply more than 0.754 lb/acre per season. If an application of imidacloprid (Admire Pro) was made at planting, choose another treatment material with a different mode of action group number to help prevent the development of neonicotinoid resistance.

B. SPIROTETRAMAT
   (Movento) 4.0–5.0 24 7
   MODE OF ACTION GROUP NUMBER¹: 23

C. SPIROMESIFEN
   (Oberon 2SC) 8–16 fl oz 12 7
   MODE OF ACTION GROUP NUMBER¹: 23
   COMMENTS: Apply early at the first sign of psyllid presence. Do not exceed two applications/crop or make applications at less than 7-day intervals.
** See label for dilution rates.
‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.
* Permit required from county agricultural commissioner for purchase or use.
NA Not applicable

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 for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee)

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**Important Links**

- [Surveying foliage pests form](#) (PDF)

Text updated: 4/19
Treatment table updated: 4/19
Wireworms

Dryland wireworm: *Ctenicera pruinina*

Pacific coast wireworm (Click beetle): *Limonius canus*

Sugarbeet wireworm: *Limonius californicus*

**Description of the Pest**

Wireworms are the soil-dwelling larvae of click beetles. Several wireworm species occur in western potato soils, but the most common are the Pacific coast wireworm, the sugarbeet wireworm, and the dryland wireworm. Several species of the genus *Conoderus* have also been encountered in some production areas.

*Adult* wireworms are slender, reddish brown to black click beetles that are 0.25 to 0.5 inch long. The *larvae* are wirelike, having hard bodies that are slender, cylindrical, yellowish to brown in color, and about 0.75 inch long when full grown. Common wireworm species require 3 to 4 years to complete their life cycle. Most of the time is spent in the larval stage, but all stages may be present at once during the growing season.

**Damage**

Adults do not damage potatoes, but the larvae, or wireworms, may damage seed pieces and young root systems during stand establishment, resulting in poor stands. More commonly the damage is seen as shallow to *deep holes* in the potatoes, caused by wireworms burrowing into the tuber while feeding. Wireworms bore perpendicularly or diagonally to depths up to 0.5 inch, but do not tunnel all the way through the tuber.

**Management**

The best time to manage wireworms is before planting. Check for wireworms by observing the field during plowing or discing, or by baiting. If wireworms are present, monitor by taking soil samples to determine the need to treat.

**Cultural Control**

In recent years, wireworms have been most common in the northern mountain areas in fields that have been in weedy alfalfa or pasture for several years before potatoes. Avoid planting potatoes in fields immediately following clover, grass, pasture, or weedy alfalfa. Summer fallow will reduce wireworm numbers by drying the soil.

**Organically Acceptable Methods**
Use cultural controls on an organically certified potato.

**Monitoring and Treatment Decisions**

The most direct way to detect wireworms in a field is by general observation during plowing or discing of a field, particularly where old alfalfa, clover, or pasture is being taken out. Wireworms can also be detected by baiting, using carrots, packets of untreated corn and/or wheat seed, or ground whole wheat flour, provided they are used when soil temperatures are 50°F at 4 to 6 inches deep. Baiting does not give a good estimation of the density of the population. If baiting shows the presence of wireworms, take soil samples to estimate the wireworm density. Use a 6-inch post hole digger and a shaker/sifter to sample. Take samples in spring when soil temperatures are 45°F or higher at the 6-inch level or in late summer at the 18-inch level. The following guide is used in some production areas.

<table>
<thead>
<tr>
<th>Acres in field</th>
<th>Number of soil samples</th>
<th>Treatment threshold (# of wireworms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>45</td>
<td>2</td>
</tr>
<tr>
<td>40</td>
<td>60</td>
<td>2</td>
</tr>
<tr>
<td>90</td>
<td>90</td>
<td>4</td>
</tr>
<tr>
<td>160</td>
<td>120</td>
<td>5</td>
</tr>
</tbody>
</table>

Preplant broadcast treatments have provided adequate control in limited field tests conducted in California. Band treatments are used in some areas, but have not been evaluated under California conditions. In areas where potatoes are planted in late fall and winter, soil-applied insecticides tend to break down before wireworms become active when the soil warms in spring.

<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>IMIDACLOPRID (Admire Pro)</td>
<td>5.7–8.7 fl oz</td>
<td>12</td>
<td>NA</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply to soil following label directions. Do not exceed 8.7 fl oz/acre/crop.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>THIAMETHOXAM/FLUDIOXONIL (Cruiser Maxx Potato)</td>
<td>Label rates</td>
<td>12</td>
<td>NA</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Read label for rotational restrictions following the application of this material.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ETHOPROP (Mocap)</td>
<td>Label rates</td>
<td>72</td>
<td>NA</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NUMBER‡: 1B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Broadcast or spray on soil and thoroughly work into the soil to a depth of 2 to 4 inches before planting. Soil temperature must be 50°F or higher when ethoprop is applied. May also be applied at planting or before crop emergence.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** See label for dilution rates.
‡ 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.

NA Not applicable

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

1 Rotate chemicals 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; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode of action group numbers are assigned by IRAC (Insecticide Resistance Action Committee).

Text updated: 4/19
Treatment table updated: 4/19
Diseases

Bacterial Ring Rot

*Clavibacter michiganensis* subsp. *sepedonicus*

**Symptoms and Signs**

Foliar symptoms of bacterial ring rot generally appear at mid-season or later. Yellow areas develop on leaf margins or between veins and later turn brown, giving the leaves a burned appearance. Plants with advanced symptoms show vascular discoloration and milky, viscous bacteria may be forced from cut stems. In tubers, symptoms may occur before harvest or in storage. Rot begins as a brown necrosis in the vascular ring and progresses to surface. Cracks may appear on surfaces of tubers, which are frequently nothing more than hollow shells.

**Comments on the Disease**

The bacterial ring rot bacterium overwinters in infected tubers. It does not live freely in the soil, but it can survive for long periods as a dried slime on harvesting and grading machinery, sacks, etc. A wound is required for infection and spread occurs most commonly when seed is cut.

**Management**

Use only certified seed tubers, rotate out of potatoes at least one year, and follow strict sanitation procedures when handling and cutting seed. Disinfect cutting tools between seed lots using a 1% solution of calcium hypochlorite or another appropriate sanitizer. Use of whole-drop seed will minimize spread. Cup-type planters will spread the pathogen less than pick-type.

Text updated: 3/19
Bacterial Soft Rot and Blackleg

Bacterial soft rot: *Pectobacterium (=Erwinia) carotovorum ssp. carotovorum*, *Dickeya (=Erwinia) chrysanthemi*

Blackleg: *Pectobacterium (=Erwinia) atrosepticum*

**Symptoms and Signs**

**Soft rot**

Symptoms of soft rot include soft, wet, rotted, tan or cream-colored tissues. Rot begins on the tuber surface and progresses inward. Infected tissues are sharply delineated from healthy tissue by dark brown or **black margins**. Shallow necrotic spots on the tubers result from infections through lenticels. Rotting tissue is usually odorless in the early stages of decay but develops a foul odor as secondary organisms invade infected tissue. Soft rot can also infect wounded stems and roots.

**Blackleg**

Plants with blackleg are stunted and have a stiff, erect growth habit. Foliage becomes chlorotic and the leaflets tend to roll upward at the margins. Plants generally are wilted. Stems of infected plants exhibit an inky **black decay**. The base of the stem is often completely rotted. In relatively dry soil, only the pith may show blackening. Tuber symptoms for blackleg are similar to those of soft rot. The soft rot *Pectobacterium* spp. may cause **wilting** but affected plants lack the characteristic inky black stem decay.

**Comments on the Disease**

**Soft rot**

Bacteria are present on all tubers and are associated with many kinds of plants. Infections in the field are favored by high soil moisture and high temperatures. Other factors include anaerobic conditions, **enlarged lenticels**, and invasion by other pathogens. Bacteria enter lenticels, growth cracks, or any injury. During and after harvest, soft rot is favored by immature tubers, adverse temperatures (pulp temperatures above 70°F at harvest), mechanical damage, and free water on tuber surfaces.

**Blackleg**

Blackleg inoculum comes primarily from infected seed tubers, but it may also be spread in infested soil, contaminated irrigation water, and by insects. Blackleg is favored by cool, wet conditions at planting followed by high temperatures after emergence.

**Management**
The pathogens that cause these diseases occur wherever potatoes are grown. The severity of the disease depends on seed-handling techniques, soil moisture and temperature at planting, environmental conditions, cultivar, physiological condition of the seed, amount of infection in the seed lot used, and external sources of the bacteria such as irrigation water and cull piles.

**Cultural Control**

**Soft rot**

Use high quality seed. Split applications of water-soluble calcium applied at 100 to 200 pounds per acre during bulking have been shown to reduce infection and severity of soft rot. Harvest mature tubers with low pulp temperature and well-set skins, and avoid mechanical injury. Avoid excessive soil moisture before harvest to reduce lenticel infection; use clean water to wash potatoes; and avoid water films on tuber surfaces during storage. Postharvest [curing and storage temperatures](#) can be a critical component of soft rot management. Specific temperature recommendations vary depending on the level of decay evident at packing and the market destiny of the potatoes (i.e., processing, fresh market, or long-term storage); for details, consult your local farm advisor or the reference *Potato Health Management, Second Edition* (Johnson DA, ed. 2007. St. Paul, MN: The American Phytopathological Society).

**Blackleg**

Use pathogen-free tubers for seed. Warm seed tubers to about 55°F before planting. Provide good drainage and do not over irrigate. Eliminate cull piles and potato volunteers in rotation crops and adjacent fields.

**Treatment Decisions**

Fungicides do not directly affect these bacterial pathogens, but seed piece treatments with fungicides can reduce invasion by other fungi and therefore reduce opportunistic infection by *Plectobacterium* spp. Watch for disease symptoms during routine monitoring, and keep records of your results ([example form](#)). Maintaining chlorinate recirculated wash water with a concentration of 50 to 200 ppm, depending on potato variety, is particularly important when harvesting tubers with warmer pulp temperature directly from the field.

<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>SEED TREATMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. FLUDIOXONIL/MANCOZEB (Maxim MZ)</td>
<td>0.5 lb/100 lb cut seed pieces</td>
<td>See label</td>
<td>NA</td>
</tr>
</tbody>
</table>

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide’s properties and application timing, [honey bees](#), and [environmental impact](#). Always read the label of the product being used.
<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>IN FURROW</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. BA CILLUS SUBTILIS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Serenade ASO)#</td>
<td>2–4 qts</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

**MODE-OF-ACTION GROUP NAME (NUMBER1):** Microbial (44)

**COMMENTS:** In-furrow application of Serenade at planting has shown to reduce incidence of soft rot.

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

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

NA Not applicable

# Acceptable for use on organically grown produce.

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**Important Links**

- [Surveying foliage pests form](#) (PDF)

Text updated: 3/19
Treatment table updated: 3/19
Black Dot

Colletotrichum coccodes

Symptoms and Signs

Black dot is a disease that affects roots, stems and tubers and is named for the small black, dot-like structures (sclerotia) that form on the surface of infected stems, stolons, and tubers. Black dot first appears in mid- to late season as a yellowing and wilting of plants. These symptoms are easily confused with *Verticillium wilt* or early dying associated with bacterial soft rot. Wilting caused by black dot develops rapidly, in contrast to *Verticillium* wilt.

The black dot pathogen can cause severe decay of the cortical tissue of roots. Affected roots may appear stringy when pulled from the soil. In some cases, lesions on belowground stems and stolons may be confused with Rhizoctonia stem and stolon canker; however, black dot lesions are darker. In Tulelake, infected roots often lack dark lesions. The cortical tissue scales away, exposing the woody vascular tissue, which gives the roots a stringy, water-soaked appearance, amethyst in color. Small, dark, dotlike fungal structures (sclerotia) are almost always present near soil level with mature infections. Spore-forming structures (acervuli) with conspicuous hairs (setae) also are formed. Tubers infected with black dot appear to have a slightly darker or a rash-like appearance that closely resembles silver scurf. Presence of sclerotia distinguish black dot from silver scurf. Tuber blemishes are easy to see particularly when tubers are wet. Another common symptom of black dot is the adherence of stolons to the stem ends of tubers.

Comments on the Disease

Black dot affects other plants in the potato family, including tomatoes, eggplants, and peppers. The fungus that causes black dot, *Colletotrichum coccodes*, survives as sclerotia, which form on tubers, stolons, roots, and stems at the end of the season. The pathogen can be introduced into clean fields via contaminated seed tubers, and disease levels increase in fields with a short cropping history between susceptible crops. Sclerotia can survive for long periods on plant debris in the soil. Spores produced in acervuli on aboveground plant parts can be spread by wind to other plants and cause infections if wounds are present.

The black dot pathogen often invades plants that are weakened by other diseases, and it may accelerate early death of vines infected with *Verticillium, Pectobacterium (Erwinia)*, and possibly *Phytophthora*. Black dot occurs most frequently on plants grown in coarse-textured soils under conditions of low or excessively high nitrogen, high temperature, or poor soil drainage. Black dot infections are increased by windblown sand, which can cause abrasions that give the pathogen easy access.
Management

Plant certified seed tubers, maintain adequate levels of nutrients, and avoid overirrigation. When fields become infested, rotate to nonhost crops such as grains for at least 3 years, and control potato volunteers and potato family weeds in the rotation crops. No potato cultivars are resistant, but early season cultivars may escape some damage in infested fields, and the tubers of russet cultivars are less severely affected than tubers of thinner-skinned cultivars.

Efficacy trials evaluating different fungicides have shown that although there are several fungicides available that can reduce root rot and foliage symptoms, none was able to significantly decrease the occurrence of tuber blemish.

<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. AZOXYSTROBIN
   (Quadris Flowable, etc.) 0.4–0.8 fl oz/1000 row feet 4 14
   MODE-OF-ACTION GROUP NAME (NUMBER$: Quinone outside inhibitor (11)
   COMMENTS: Do not apply more than 2.88 qt/season. QoI group: At high risk for resistance development. Resistance is known to occur in various fungal species.

B. AZOXYSTROBIN/DIFENOCONAZOLE
   (Quadris Top) 8–14 fl oz 12 14
   MODE-OF-ACTION GROUP NAME (NUMBER$: Quinone outside inhibitor (11)/ demethylation inhibitors (3)
   COMMENTS: Do not apply more than 55.3 fl oz per season of Quadris Top, 0.46 lb a.i. per acre per season of difenoconazole-containing products, and not more than 2.0 lb a.i. of azoxystrobin-containing products.

C. MANDIPROPAMID/DIFENOCONAZOLE
   (Revus Top) 5.5–7.0 fl oz 12 14
   MODE-OF-ACTION GROUP NAME (NUMBER$: carboxylic acid amides (40)/ demethylation inhibitors (3)
   COMMENTS: Do not apply more than 28 fl oz per season of Revus Top, 0.52 lb a.i. per acre per season of mandipropamid-containing products, and not more than 0.46 lb a.i. of difenoconazole-containing products.

D. BOSCALID
   (Endura) 2.5–4.5 oz 12 10
   MODE-OF-ACTION GROUP NAME (NUMBER$: Succinate dehydrogenase inhibitors (7)
   COMMENTS: No more than 20 oz per acre per year allowed.

E. FAMOXADONE/CYMOXANIL
   (Tanos) 6–8 oz 12 14
   MODE-OF-ACTION GROUP NAME (NUMBER$: Quinone outside inhibitor (11)/ Cyanoacetamide-oxime (27)
   COMMENTS: For best results suppressing Black Dot, tank-mix with a mancozeb or maneb fungicide.

F. PYRACLOSTROBIN
   (Headline) 6–9 fl oz 12 3
   MODE-OF-ACTION GROUP NAME (NUMBER$: Quinone outside inhibitor (11)
   COMMENTS: QoI group: At high risk for resistance development. Resistance is known to occur in various fungal species.
† 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.

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Text updated: 3/19
Calico

*Alfalfa mosaic virus* (AMV)

**Symptoms and Signs**

Calico symptoms on potato appear as pale to bright yellow or blotching of leaves. Some strains cause *severe stunting* and necrosis of stems and tubers. Dry, corky areas or rusty brown patches develop within tubers.

**Comments on the Disease**

*Alfalfa mosaic virus* is transmitted by many species of aphids. Transmission of the virus is most likely to occur when aphids migrate into potato fields from nearby alfalfa or clover fields, the usual hosts for this virus. Infection often occurs on edges of fields located near alfalfa. Little or no secondary spread occurs within the potato field.

**Management**

Plant certified seed tubers and avoid planting near alfalfa or clover.

Text updated: 3/19
Charcoal Rot

*Macrophomina phaseolina*

**Symptoms and Signs**

Charcoal rot symptoms appear during hot weather when foliage of affected plants wilts and turns yellow, symptoms that may be confused with Verticillium wilt or bacterial early dying. Wilting caused by *Macrophomina* usually develops quickly, in contrast to Verticillium wilt.

Infected stems develop a soft, dark rot similar to blackleg. Affected stems take on a dusty black appearance when small, black fungal structures (microsclerotia) are formed. This “charcoal dust” symptom, sometimes called ashy stem blight, helps distinguish charcoal rot from other stem rot diseases.

Tubers can be infected by *Macrophomina* before harvest. Infections occur around eyes, in lenticels that are enlarged because of high soil moisture, and where the stolon attaches. Shallow, water-soaked lesions develop. Tuber tissue within these lesions turns gray, and eventually the lesion tissue becomes filled with black fungal mycelium. If tuber infections develop quickly, much of the tuber tissue may develop a soft rot that turns from white to pink and then black, similar to pink rot, when diseased tubers are cut open.

**Comments on the Disease**

Charcoal rot affects a wide range of crop plants including other solanaceous crops, beans, corn, and cucurbits. The disease becomes economically important only when soil moisture is high and soil temperature is above 82°F. In California, it is an important disease of potato only in the Central Valley.

The fungus that causes charcoal rot survives as microsclerotia that form on infected host tissue. The pathogen can be spread on contaminated seed tubers. Microsclerotia can survive for long periods on plant debris in the soil. Tubers are predisposed to infection when soil temperatures are 90°F or higher.

**Management**

Plant certified seed tubers. No potato cultivars are resistant, but early-season cultivars may escape damage in infested fields. Harvest as soon as tubers have matured and, when possible, before soil temperature exceeds 82°F. Avoid injuring tubers during harvest. Rotation to nonhost crops for several years is required to reduce incidence of the disease.

Text updated: 3/19
Common Scab

*Streptomyces* spp.

**Symptoms and Signs**

Tuber symptoms of common scab vary in extent and appearance. Common scab lesions are usually circular and 0.25 to 0.33 inch (6 to 8 mm) in diameter, but they can be smaller in early stages of development and larger if they coalesce. Lesions typically possess a raised margin and slightly depressed center. Some characteristic symptoms have descriptive names: russet scab appears on tubers as superficial tan to brown *corky lesions*; pitted scab is characterized by lesions with *depressions* beneath the tuber surface; and raised scab appears as cushionlike, warty lesions. Common scab lesions can be confused with tuber lesions of *powdery scab* caused by *Spongospora subterranea* and patchy russetting caused by *Rhizoctonia solani*. In addition to tuber symptoms, *Streptomyces* spp. can cause brown stem and stolon lesions.

**Comments on the Disease**

*Streptomyces* spp. are widely distributed and persist in soil on decaying organic matter. Inoculum is also carried on infected seed tubers. Disease severity is usually increased by continuous cropping to potatoes. Tubers become susceptible to infection when they start forming. Scab lesions expand as the infected tubers grow. Mature tubers with well-developed skins are not susceptible. The fungus can also persist in un-composted manure from animals that have fed on infested tubers. When done properly, however, composting can apparently destroy infective inoculum of *Streptomyces*. Infection is favored by warm dry soils. A relatively low soil pH (5.5) inhibits scab, but *S. acidiscabes* can cause scab in soils at less than pH 5.5.

**Management**

Maintaining high soil moisture (80–90% of available water storage) during tuber initiation and the 6 to 8 weeks that follow reduces the severity of scab and usually controls the disease adequately. Other practices that help reduce the incidence of scab include crop rotation with green manure crops such as rye, millet, and oats; whereas, rotations with carrots, beets, spinach, turnip, and radish are not advisable. Avoid soil application of animal wastes, since the pathogen survives passage through the digestive tract. Use certified seed tubers free from common scab. Contact your local farm advisor about relative resistance of varieties that are adapted to your area.

When applied before planting, some soil amendments such as sulfur and triple superphosphate help to increase soil pH, which makes the soil less favorable to disease development. Your local farm advisor can provide information on amounts that are appropriate for your soil conditions.

Text updated: 3/19
Corky Ringspot

*Tobacco rattle virus* (TRV)

**Symptoms and Signs**

Aboveground symptoms of corky ringspot rarely occur. Symptoms in tubers vary depending on virus strain, potato variety, temperature, and time of infection. Symptoms of tubers can occur both externally or internally depending on cultivar. Arcs of discolored tissue can be seen on tuber surfaces; particularly on smooth skin cultivars, though internal symptoms are more common. Internal symptoms can be small flecks, necrotic rings, or large necrotic/corky areas in tubers. Internal flecks can be confused with alfalfa mosaic virus.

**Comments on the Disease**

*Tobacco rattle virus* is transmitted by stubby root nematodes (*Paratrichodorus* spp.). Young potato roots and tubers are infected with tobacco rattle virus when virus-infected nematodes feed on them. The virus is also transmitted in infected tubers. Other hosts of the virus include *nightshades*, *pigweeds*, *shepherd’s-purse*, *purslane*, *cocklebur*, and *sunflower*.

**Management**

Plant certified seed tubers and avoid fields with a history of corky ringspot. If planting in fields with history of corky ringspot and high numbers of stubby root nematodes, fumigation may be warranted to prevent severe damage.

<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. 1,3-DICHLOROPROPENE*§</td>
<td>Label rates</td>
<td>See label</td>
<td>NA</td>
</tr>
<tr>
<td>(Telone)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. METAM SODIUM*§</td>
<td>37.5–75 gal</td>
<td>See label</td>
<td>NA</td>
</tr>
<tr>
<td>(Vapam)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. METAM POTASSIUM*§</td>
<td>Label rates</td>
<td>See label</td>
<td>NA</td>
</tr>
<tr>
<td>(K-Pam)</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. 1,3-DICHLOROPROPENE*§**

- Label rates
- See label
- NA

**B. METAM SODIUM*§**

- 37.5–75 gal
- See label
- NA

**C. METAM POTASSIUM*§**

- Label rates
- See label
- NA

**NA** Not applicable

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

§ Do not exceed the maximum rates allowed under the California Code of Regulations Restricted Materials Use Requirements, which may be lower than maximum label rates.
Text updated: 3/19
Cucumber Mosaic

*Cucumfera mosaic virus* (CMV)

**Symptoms and Signs**

Cucumber mosaic appears as a chlorosis and blistering mottle of leaves. Margins of leaves are wavy. Intense yellow flecks may develop over the leaf surface. Plants are stunted.

**Comments on the Disease**

*Cucumfera mosaic virus* infects many crops and weeds. The virus is transmitted by many species of aphids. The disease is only an economical problem in potato when potatoes are planted next to or in the immediate vicinity of another crop heavily infested with the virus and aphids. Cucumber mosaic is an occasional problem in Kern County in potatoes planted near blackeye bean fields that harbor the virus.

**Management**

Do not plant potatoes near crops heavily infested with aphids and infected with cucumber mosaic virus.

Text updated: 3/19
Curly Top

_Beet curly top virus_ (BCTV)

**Symptoms and Signs**

Curly top symptoms include dwarfing, yellowing, and rolling of upper leaves. Leaves near the growing point develop yellow margins and become twisted and cupped. Veins of outer leaflets remain green while the rest of the leaflet turns yellow. Aerial tubers may form.

**Comments on the Disease**

The virus is transmitted by the _beet leafhopper_, _Curculifer tenellus_. Curly top affects a wide range of crops and weeds. Both the virus and the leafhopper survive on a large number of wild plants and weeds.

**Management**

To prevent curly top outbreaks, the California Department of Food and Agriculture carries out a statewide monitoring and treatment program for the beet leafhopper vector. Beet leafhopper populations are monitored in foothill areas in spring. Locations where high populations have congregated are sprayed before they can move into agricultural fields. Treatment of beet leafhopper by growers is not suggested for preventing curly top.

Text updated: 3/19
Diseases Caused by Phytoplasmas

Beet leafhopper transmitted virescence agent (BLTVA) and western aster yellows

Symptoms and Signs

Symptoms of diseases caused by mycoplasmalike organisms include stunted growth, chlorotic or reddened leaves, leafroll, reduced numbers of subterranean tubers, sexual bud elongation, and the production of aerial tubers. Some plants exhibit witches'-broom symptoms, i.e., the proliferation of many small shoots and leaves. Symptoms may be confused with damage caused by psyllid insects and, in some cases, with leafroll virus.

Comments on the Disease

These diseases are uncommon in California. Beet leafhopper transmitted virescence agent is transmitted by the beet leafhopper, *Circulifer tenellus*; western aster yellows is transmitted by another leafhopper, *Macrosteles fascifrons*. Both mycoplasmalike organisms occur in other herbaceous plants. The incidence of the disease is dependent on the abundance of the leafhopper vectors and the reservoir of the mycoplasmalike organisms.

Management

Although these diseases rarely cause economic damage in California, they are often found in fields with weedy edges or with weedy areas nearby. Controlling weeds near potato fields helps to prevent development of these diseases.

Text updated: 3/19
Early Blight

*Alternaria solani*

**Symptoms and Signs**

Early blight is primarily a disease of stressed or senescing plants. Symptoms appear first on the oldest foliage. Affected leaves develop circular to angular dark brown lesions 0.12 to 0.16 inch (3–4 mm) in diameter. Concentric rings often form in lesions to produce characteristic target-board effect. Severely infected leaves turn yellow and drop. Infected tubers show a brown, corky dry rot.

**Comments on the Disease**

Between crops, the early blight fungus can overwinter on potato refuse in the field, in soil, on tubers, and on other solanaceous plants. Infection occurs when spores of the fungus come in contact with susceptible leaves and sufficient free moisture is present. Spore germination and infection are favored by warm weather and wet conditions from dew, rain, or sprinkler irrigation. Alternately, wet and dry periods with relatively dry, windy conditions favor spore dispersal and disease spread. Tubers can be infected as they are lifted through the soil at harvest. If sufficient moisture is present, spores germinate and infect the tubers.

**Management**

Early blight can be minimized by maintaining optimum growing conditions, including proper fertilization, irrigation, and management of other pests. Grow later maturing, longer season varieties. Fungicide application is justified only when the disease is initiated early enough to cause economic loss. Watch for disease symptoms during routine monitoring, and keep records of your results (example form—PDF). When justified, apply fungicides as soon as symptoms appear; continued protection requires application at 7- to 10-day intervals.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
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</thead>
<tbody>
<tr>
<td><strong>A. AZOXYSTROBIN</strong>&lt;br&gt;(Quadris)</td>
<td>6.2–15.4 oz</td>
<td>See label</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER1): Quinone outside inhibitor (11)</td>
<td>COMMENTS: Do not apply more than 2.88 qt per season.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. BOSCALID</strong>&lt;br&gt;(Endura)</td>
<td>2.5–4.5 oz</td>
<td>12</td>
<td>10</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.
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</thead>
<tbody>
<tr>
<td><strong>C. CHLOROTHALONIL</strong> (various products)</td>
<td>Label rates</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td><strong>MODE OF ACTION GROUP NAME (NUMBER¹):</strong> Succinate dehydrogenase inhibitors (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D. FAMOXADONE/CYMOXANIL</strong> (Tanos)</td>
<td>6 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td><strong>MODE OF ACTION GROUP NAME (NUMBER¹):</strong> Chloronitriles (phthalonitriles) (M5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E. FENAMIDONE</strong> (Reason 500SC)</td>
<td>5.5–8.2 fl oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td><strong>MODE OF ACTION GROUP NAME (NUMBER¹):</strong> Quinone outside inhibitor (11)/Cyanoacetamide (27)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>F. IPRODIONE</strong> (Rovral 4F)</td>
<td>2 pt</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td><strong>MODE OF ACTION GROUP NAME (NUMBER¹):</strong> Dicarboximide (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G. MANCOZEB</strong> (various products)</td>
<td>Label rates</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td><strong>MODE OF ACTION GROUP NAME (NUMBER¹):</strong> Dithiocarbamates and relatives (M3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>H. PYRACLOSTROBIN</strong> (Headline)</td>
<td>6–9 fl oz</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td><strong>MODE OF ACTION GROUP NAME (NUMBER¹):</strong> Quinone outside inhibitor (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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

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### Important Links

- [Surveying for foliage pests](#) (PDF)

Text updated: 3/19
Treatment table updated: 3/19
Fusarium Dry Rot and Seed Piece Decay

*Fusarium* spp.

**Symptoms and Signs**

*Fusarium* causes a dry rot of infected tubers, although a moist rot may occur if secondary infection by soft rot bacteria is also involved. Initially, lesions appear as brown to black flecks on the tuber surface. Lesions later form large, hollow cavities. Frequently, the lesions appear wrinkled on the tuber surface with numerous white tufts of mycelium. Infected seed pieces may completely decay.

**Comments on the Disease**

*Fusarium* spp. are present in all soils and are found on the surface of all tubers. Wounds are required for infection. *Fusarium* cannot penetrate intact tuber skin, lenticels, or suberized (healed) seed pieces.

**Management**

Proper handling and curing is usually sufficient to give economic control of dry rot in storage. Allow tubers to mature before harvest and prevent damage to tubers during harvest and storage operations. Wound healing reduces infection by *Fusarium*; to speed the healing process, hold tubers at 50° to 55°F with good ventilation and a relative humidity of at least 95% for the first 2 to 3 weeks of storage.

Seed piece decay is reduced when seed pieces are planted under conditions that favor rapid suberization; *Fusarium* cannot infect cut surfaces after they are suberized. Warm the seed tubers to 50°F before cutting, and keep cutting and handling equipment disinfected. Plant when the soil temperature is at least 45°F and when soil moisture is 60 to 80% of field capacity. Plant seed with a pulp temperature warmer than the soil temperature. If possible, avoid irrigation before emergence. When planting conditions are likely to favor seed piece decay, treat cut seed pieces with a fungicide.

### SEED TREATMENT

A. **FLUDIOXONIL**

*(Maxim PSP)*

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount to Use</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLUDIOXONIL</td>
<td>0.5 lb/100 lb seed pieces</td>
<td>12</td>
<td>NA</td>
</tr>
</tbody>
</table>

**MODE OF ACTION GROUP NAME (NUMBER):** Phenylpyrrole (12)

B. **FLUTOLANIL/MANCOZEB**
<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount to Use</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MonCoat MZ</td>
<td>0.75–1 lb/100 lb seed pieces</td>
<td>24</td>
<td>NA</td>
</tr>
</tbody>
</table>

**POSTHARVEST - STORED POTATO TUBERS**

**A. AZOXYSTROBIN/FLUDIOXONIL/DIFENOCONAZOLE**

(Stadium) 1.0 fl oz/2,000 lb of tubers  NA  NA

**MODE OF ACTION GROUP NAME (NUMBER\(^1\)):** Succinate dehydrogenase inhibitors (7)/dithiocarbamates and relatives (M3)

**B. PHOSPHITES**

(Phostrol) 0.1 gallon / ton of tubers/0.5 gal  4  NA

**MODE OF ACTION GROUP NAME (NUMBER\(^1\)):** Quinone outside inhibitors (11)/PhenylPyrroles (12)/DeMethylation inhibitors (3)

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

\(1\) Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action group number. NA Not applicable

Text updated: 3/19
Treatment table updated: 3/19
Fusarium Wilt

*Fusarium solani* f. sp. *eumartii*

**Symptoms and Signs**

Fusarium wilt symptoms resemble those of Verticillium wilt. Lower leaves of infected plants turn yellow and wilt. Leaf tissue between veins turns yellow then brown. Wilting and yellowing of foliage progresses up the stems of affected plants. Vascular tissue in stems and tubers often develops a brown discoloration; typically there is a stem end rot of the tubers. Wilt symptoms are more severe when temperatures are high and plants are stressed for water. Laboratory analysis of diseased plant tissue usually is necessary to determine whether *Fusarium* or *Verticillium* is the causal agent. In most areas Verticillium wilt is more common than Fusarium wilt.

**Comments on the Disease**

Fusarium wilt is a minor problem of potatoes grown in the San Joaquin Delta. It occurs rarely in other potato-growing areas of California. The fungus that causes Fusarium wilt can survive in the soil for several years in the absence of hosts. The roots of susceptible host plants are infected, and the pathogen moves up in the vascular tissue to infect stems, stolons, and tubers. The pathogen can be introduced to clean ground in infected seed tubers.

**Management**

Plant disease-free seed tubers. Avoid growing seed potatoes in ground known to be infested with the Fusarium wilt pathogen. Rotation out of potatoes or other solanaceous crops for 4 to 6 years is necessary to reduce soil inoculum levels.

Text updated: 3/19
Late Blight
Phytophthora infestans

Symptoms and Signs
Late blight lesions can occur on all aboveground plant parts. On leaves, lesions typically first appear as small pale to dark green water-soaked spots that are irregular in shape and surrounded by a zone of yellowish tissue. Under conducive conditions, lesions expand rapidly and become brown to purplish black as tissue is killed. Under sufficient humidity, white sporulation of the fungus can be observed at the periphery of lesions, principally on the underside of leaves. On stems and petioles, lesions are brown to black and may also support sporulation of the fungus. Infected tubers develop a firm brown decay that starts on the outside and may later extend to include the outer 0.125 to 0.5 inch (3–12 mm) of tissues.

Comments on the Disease
Late blight occurs commonly in coastal environments and in the southern San Joaquin Valley in California. In other California potato-growing areas its occurrence is sporadic, depending on the presence of the pathogen and cool, damp weather conditions. Inoculum of Phytophthora infestans can originate from seed tubers, cull piles, volunteers, closely related weed hosts such as nightshade, and adjacent plantings of potatoes or tomatoes that are affected. Late blight can develop and spread rapidly if inoculum is present and conditions are conducive. High humidity (above 90%) and average temperatures in the range of 50° to 78°F favor the disease.

Management
Late blight is controlled by eliminating cull piles and volunteer potatoes, using proper harvesting and storage practices, and applying fungicides when necessary. Air drainage to facilitate the drying of foliage each day is important. Under marginal conditions, overhead sprinkler irrigation can favor late blight; in Tule Lake under solid set sprinklers, conditions conducive to late blight development are enhanced by day time irrigation but not night time irrigation.

Plant certified seed tubers. When late blight has developed on foliage and tubers are at risk of infection, make sure that vines are completely dead for 2 to 3 weeks before harvest. Phytophthora infestans does not survive very long in dead foliage.

In districts that are commonly subjected to outbreaks of late blight, preventive applications of fungicides are advised when environmental conditions are favorable for the disease. Continue fungicide applications at 7- to 10-day intervals as conditions require. Shorter intervals may be needed under cool, rainy conditions. In interior districts where late blight occurs sporadically, watch for disease symptoms during
routine field monitoring, and record your results (example form—PDF). Apply fungicides when late blight lesions appear in the field or in nearby plantings.

Strains of *Phytophthora infestans* have developed resistance to mefenoxam (Ridomil Gold).

<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. AZOXYSTROBIN</strong> (Quadris)</td>
<td>6.2–15.4 fl oz</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Quinone outside inhibitor (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. CYMOXANIL</strong> (Curzate 60 DF)</td>
<td>3.2 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Cyanoacetamide-oxime (27)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Use only in combination with a protectant fungicide (e.g., mancozeb, chlorothalonil). For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Begin applications when conditions are conducive to disease development, repeat at 5- to 7-day intervals. Do not exceed 7 applications/growing season (see label for additional restrictions).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. CHLOROTHALONIL</strong> (various products)</td>
<td>Label rates</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Chloronitrides (phthalonitrides) (M5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D. DIMETHOMORPH</strong> (Forum)</td>
<td>4–6 oz</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Carboxylic acid amides (40)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Begin applications when plants are 4 to 6 inches high or at onset of disease. See label for additional information.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E. FAMOXADONE/CYMOXANIL</strong> (Tanos)</td>
<td>6–8 oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Quinone outside inhibitor (11)/ Cyanoacetamide-oxime (27)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: For best results suppressing Black Dot, tank-mix with a mancozeb or maneb fungicide.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>F. FENAMIDONE</strong> (Reason 500SC)</td>
<td>5.5–8.2 fl oz</td>
<td>12</td>
<td>14</td>
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<td>MODE OF ACTION GROUP NAME (NUMBER¹): Quinone outside inhibitor (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G. MANCOZEB</strong> (various products)</td>
<td>Label rates</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Dithiocarbamates and relatives (M3)</td>
<td></td>
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</thead>
<tbody>
<tr>
<td><strong>H. MEFENOXAM/CHLOROTHALONIL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Ridomil Gold Bravo SC)</td>
<td>2.5 pts</td>
<td>48</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Phenylamide (4)/Chloronitriles (phthalonitriles) (M5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>. . . or . . .</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MEFENOXAM/COPPER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Ridomil Gold Copper)</td>
<td>2 lb</td>
<td>48</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Phenylamide (4)/Multi-site contact (M1)</td>
<td></td>
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<tr>
<td><strong>. . . or . . .</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MEFENOXAM/MANCOZEB</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Ridomil Gold MZ)</td>
<td>2.5 lb</td>
<td>48</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Phenylamide (4)/Multi-site contact (M3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMMENTS</strong>: Apply Ridomil Gold Copper with 0.8 lb a.i. per acre of mancozeb or chlorothalonil. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I. PROPAMOCARB HYDROCHLORIDE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Previcur Flex)</td>
<td>0.7–1.2 pt</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Carbamate (28)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMMENTS</strong>: Apply as a tank mix with chlorothalonil or mancozeb in a preventive program. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i. Do not apply more than 6 pt/growing season.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>J. PYRACLOSTROBIN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Headline)</td>
<td>6–12 oz</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER¹): Quinone outside inhibitor (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**POSTHARVEST - STORED POTATO TUBERS**

| **A. PHOSPHITES**               |                 |              |             |
| (Phostrol)                      | 0.1 gallon/ton of tubers/0.5 gal | 4 | NA |
| **MODE-OF-ACTION GROUP NAME (NUMBER1):** Phosphonates (33) | | | |

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

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

NA Not applicable.

**Important Links**

- [Surveying foliage pests form](#) (PDF)
Leafroll

Potato leafroll virus (PLRV)

Symptoms and Signs

The nature and severity of leafroll symptoms depend on the virus strain, potato variety, environment, and time and source of infection. Plants with chronic (seed tuberborne) infections are most severely affected. They typically are stunted and appear more erect. Lower leaves roll upwards at the margins, have a stiff leathery texture, and may die prematurely. In contrast, plants that become infected in the current season by aphid vectors of potato leafroll virus normally develop symptoms in the upper (youngest) leaves first; the leaves develop an upright orientation, become chlorotic, and roll upwards. Late-season infections are not always accompanied by symptoms. Potato leafroll virus can cause necrotic netting (net necrosis) in tuber vascular tissue of some varieties, including Russet Burbank.

Comments on the Disease

Potato leafroll virus can be introduced to a potato field by infected seed tubers or by aphids that have fed on infected potato plants. The most efficient vector of the virus is the green peach aphid. Several minutes to hours are required for the aphid vector to acquire the virus, but once the virus has been acquired, the aphid carries the virus for life. Winged aphids carried in air currents spread the virus for long distances between fields, while aphids without wings are important in plant-to-plant spread. Aphid feeding introduces potato leafroll virus into the phloem tissue where the virus multiplies, spreads, and initiates disease. Potato leafroll virus is not transmitted mechanically by machinery or contact with leaves.

Management

Use certified seed tubers. Control sources of the virus, including volunteer potatoes and scattered potato plants that are infected with potato leafroll virus early in the growing season. Complete plant resistance to potato leafroll virus is not available in popular varieties, but many available varieties do not develop tuber net necrosis.

Chemical control of potato leafroll virus is aimed at controlling aphids in order to reduce spread of the virus within a field. Apply insecticides from early to mid-season if aphids and potato leafroll virus are present. Late season vector control may offer no economic benefit if the potato variety is not susceptible to tuber net necrosis. See APHIDS for more information on managing aphids.

Text updated: 3/19
Mosaic Diseases Caused by Potyviruses

*Potato virus X, Potato virus A, and Potato virus Y*

**Symptoms and Signs**

**Potato Virus X**

Some strains of *Potato virus X* produce no visible symptoms, although yields may be reduced 15 percent or more when compared to virus-free plants. Other strains cause a mild mosaic with slight leaf crinkling under periods of low light intensity and low temperature (60° to 68°F). The additional presence of *Potato virus A* or *Y* may cause severe stunting, leaf distortion, crinkling, or browning of leaf tissue.

**Potato Virus A**

Infection of *Potato virus A* appears as light yellow mottling with slight crinkling on potato plants with mild mosaic. Margins of affected leaves may be wavy, and leaves may appear slightly rugose (i.e., rough) where veins are sunken and interveinal areas are raised. Affected plants tend to open up because the stems bend outward. Severity of symptom expression depends on weather conditions, the potato cultivar, and the strain of *Potato virus A*. Rugose symptoms are especially evident when *Potato virus A* and *Potato virus Y* are present together.

**Potato Virus Y**

Potato virus Y can have the most severe impact of the mosaic viruses, depending on the virus strain and potato cultivar. Strains of PVY include PVYO (“ordinary” strain), PVYC (“common” strain), PVYN (tuber necrosis strain) and a recombinant strain. The symptoms will vary depending on the strain of PVY, the potato cultivar and the temperature. Also mixed infections with other potyviruses can affect the symptoms expressed. Symptoms include mottling or yellowing of leaflets, leaf crinkling, and sometimes leaf drop. Veins on the underside of leaves often show necrotic areas as black streaks. Mosaic mottling of leaves is another foliar symptom of PVY. Infected plants may be stunted. Leaf mottling may be masked at low (below 50°F) or high (above 70°F) temperatures, but at high temperatures the disease can be identified by the crinkling and rugosity of the foliage. A severe crinkling of the leaves occurs when Potato viruses Y and X occur in the same plant. The necrotic strain PVYN (tuber necrosis strain) damages tubers of some cultivars, causing potato tuber necrotic ringspot disease (PTNRD). The necrotic strains of PVY exhibit only mild symptoms in potato foliage, making them difficult to manage through visual inspections of fields.

The presence of more than one of the viruses in a plant usually affects the types of symptoms and increases symptom severity. Symptoms caused by different viruses can be similar, so the type of virus usually cannot be identified by symptoms alone. Field diagnosis is often limited to calling it “mosaic virus”. Positive identification of the exact virus(es) requires the use of indicator plants, serological or DNA techniques.
Management

Potato tubers are probably the primary overwintering reservoir of these viruses; use seed certified free from viruses or with very low incidence of infected tubers. Use resistant cultivars where possible.

*Potato virus X* is present in all potato varieties unless virus free material is obtained. There is no known insect vector, but the virus is carried in tubers and can be transmitted mechanically by machinery, spray equipment, root-to-root contact, sprout-to-sprout contact, or seed cutting equipment. Control is by the use of certified seed and avoiding mechanical transmission by equipment such as seed cutting machinery.

*Potato viruses A and Y* are carried in tubers and are transmitted from plant to plant in a non-persistent manner by several species of aphids. If a virus-carrying aphid probes a potato plant, infection is instantaneous. Insecticides applied for aphid control may not consistently prevent the spread of potyviruses, since the insecticide may not kill quickly enough to prevent transmission by winged aphids moving into the field. However, preventing aphid build up in a field may help limit virus spread. See APHIDS for more information on managing aphids.

*Potato virus Y* is very difficult to control due to the fact that it has a wide host range, is transmitted by over 25 different aphid species and can also be mechanically transmitted. The use of certified seed, reducing weedy areas near potato fields and preventing aphid populations from building up are critical to managing this disease.

Text updated: 3/19
Pink Rot

Phytophthora erythroseptica

Symptoms and Signs

Pink rot appears as a decay of tubers that usually begins at or near the stem end of potatoes in the field or through eyes of potatoes in storage. Infected tissue becomes somewhat rubbery but not discolored. When an infected tuber is cut, the rotted portion is delineated by a dark line at its margin. With exposure to air, the surface of the decay turns a salmon pink color, which later turns to brown and then finally black. Roots and lower stems may also rot, causing a wilt and early dying of plants. The spread of pink rot may continue in storage.

Comments on the Disease

Pink rot is a major problem of potatoes. The pathogen survives for long periods in the soil and becomes active when the soil is saturated with water.

Management

Pink rot is most frequently seen in mature plants approaching harvest. It is much worse when saturated soil is accompanied by warm temperatures. Avoid prolonged saturation of soils during irrigation, provide good drainage, minimize wounding, and avoid harvesting wet tubers or tubers with pulp temperatures above 65°F. Maintain good airflow, avoid the accumulation of moisture on tubers, and maintain low temperatures during storage because the fungus is inactive below 40°F. In areas where pink rot is a problem, apply fungicide 2 and 4 weeks before harvest.

<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>Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. MEFENOXAM/MANCOZEB (Ridomil Gold MZ)</td>
<td>2.5 lb</td>
<td>48</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER1): Phenylamide (4) / Dithiocarbamates and relatives (M3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Make the first application at flowering and another 14 days later.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. MEFENOXAM/CHLOROTHALONIL (Ridomil Gold Bravo SC)</td>
<td>2.5 pts</td>
<td>48</td>
<td>14</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER1): Phenylamide (4) / Chloronitriles (phthalonitriles) (M5)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Make the first application at flowering and another 14 days later.</td>
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</table>

POSTHARVEST - STORED POTATO TUBERS
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<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. PHOSPHITES (Phostrol)</td>
<td>0.1 gallon/ton of tubers/0.5 gal</td>
<td>4</td>
<td>NA</td>
</tr>
</tbody>
</table>

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NA Not applicable

Text updated: 3/19
Treatment table updated: 3/19
Powdery Scab

*Spongospora subterranea*

**Symptoms and Signs**

Tubers infected with powdery scab develop small purplish brown pustules about 0.06 inch (1.5 mm) in diameter. The pustules typically become raised, brown, and wartlike as they enlarge to about 0.37 inch (9 mm) in diameter and rupture the tuber periderm. Powdery scab lesions on tubers may be confused with lesions of *common scab*, and laboratory confirmation of powdery scab is advised. Microscopic observation of mature powdery scab lesions typically reveals diagnostic dark brown spore balls of the causal fungus. In addition to tuber symptoms, *S. subterranea* causes *galls on roots* and stolons. Foliage symptoms have not been observed in California.

**Comments on the Disease**

The inoculum that initiates powdery scab can originate from infected seed tubers or infested soil. Once *Spongospora subterranea* is introduced into a soil, its resting spores survive indefinitely (3 to 10 years). The pathogen can also persist in un-composted manure from animals that have fed on infested tubers. When done properly, however, composting can apparently destroy infective inoculum of *S. subterranea*. In the presence of susceptible potato roots and proper environment, resting spores can germinate and release swimming zoospores that infect the host. Infection and disease development are favored by cool, wet conditions.

**Management**

Powdery scab can be minimized by using good cultural practices. Avoid planting seed tubers affected by powdery scab. Avoid planting potatoes on sites with a history of the disease. Russet varieties show less tuber damage than smooth, red- and white-skinned varieties; russet-skinned varieties rarely show tuber symptoms although root galls are common. Susceptibility varies among red and white varieties. Rotations out of potatoes for three or more years may be beneficial on some infested sites. Do not use un-composted manure from animals that have fed on tubers infested with the pathogen. Plant in well-drained soils, and avoid overirrigation. The addition of zinc sulfate (ZnSO₄) may reduce incidence of the disease. In fields with a history of powdery scab, preplant chemigation with metam sodium can reduce disease in a subsequent crop of potatoes.

<table>
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<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
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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.
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</thead>
<tbody>
<tr>
<td><strong>A. METAM SODIUM</strong>§*&lt;br&gt;(Vapam, Sectagon)</td>
<td><strong>37.5–75 gal</strong> &lt;br&gt;<strong>See label</strong></td>
<td><strong>NA</strong></td>
<td><strong>NA</strong></td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Follow manufacturer recommendations on waiting interval between treatment and planting. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs), which are a major air quality issue. Fumigate only as a last resort when other management strategies have not been successful or are not available.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>B. METAM POTASSIUM</strong>§&lt;br&gt;(K-Pam)</td>
<td><strong>Label rates</strong> &lt;br&gt;<strong>See label</strong></td>
<td><strong>NA</strong></td>
<td><strong>NA</strong></td>
</tr>
</tbody>
</table>

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

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

Text updated: 3/19
Treatment table updated: 3/19
Pythium Leak (Water Rot)

*Pythium* spp.

**Symptoms and Signs**

Pythium leak, also known as water rot, causes spongy, wet internal rot of tubers. The diseased flesh is clearly demarcated from healthy tissue by a dark boundary line. In advanced infections, hollow cavities form and all that remains of some infected tubers are tuber shells with thin papery skins.

**Comments on the Disease**

The pathogen lives in the soil and enters through wounds made during harvest. The disease is primarily a problem in Kern County and causes the most damage when saturated soil occurs along with warm temperatures.

**Management**

Avoid overwatering near harvest. Allow tubers to mature completely before harvest. Minimize bruising the tubers. In areas where leak is a problem, apply fungicide 2 and 4 weeks before harvest.

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<thead>
<tr>
<th>Common name (Example trade name)</th>
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<td>B. MEFENOXAM/CHLOROTHALONIL (Ridomil Gold Bravo SC)</td>
<td>2 pts</td>
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Text updated: 3/19
Treatment table updated: 3/19
Sclerotium Stem Rot

*Sclerotium rolfsii*

**Symptoms and Signs**

Affected stems on plants with sclerotium stem rot first show a moist decay at or slightly below the soil surface where infection is initiated. Stem lesions expand up and down the stem, and all plant parts can be infected. Stem infection leads to wilting and yellowing of the foliage. Tubers are typically infected by way of stolons. The fungus quickly grows over the tuber surface and invades, resulting in a moist cheesy decay. Portions of infected plant parts and nearby soil often are covered with the white, *radiating mycelium* of *S. rolfsii*. The mycelium generates small spherical *sclerotia* (about 1–2 mm in diameter) that are white when young and brown when mature.

**Comments on the Disease**

*S. rolfsii* attacks many field and vegetable crops in warm regions. The fungus persists in soil between crops. Germination and infection by the sclerotia are favored by hot temperatures (80° to 90°F) and moist soil surfaces. Sclerotium stem rot is considered to be a problem only in hot climate growing areas. Losses typically occur at the end of the season. The fungus can invade dead vines as well as living ones. Extensive tuber losses can be initiated within a few days of harvest if the fungus is present. Potato cultivars vary in their degree of susceptibility but current cultivars have not been well classified.

**Management**

Relatively early planting minimizes stem and tuber rot by avoiding the late season high temperatures that favor disease. Plant fields infested with *S. rolfsii* before planting fields without infestation. Do not store tubers in the ground unnecessarily long before harvest; this allows more time for infection at favorable warm temperatures. Rotate to crops that are less susceptible (e.g., nonfleshy, root or tuber crops).

Preplant chemigation with metam sodium is recommended for fields known to be infested with *S. rolfsii*; the treatment has afforded good control for at least one season. Applications of the soil amendment ammonium bicarbonate made just before harvest will kill mycelium, but not the sclerotia, of the fungus, thus preventing tuber infection for about 3 to 5 days.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
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</thead>
<tbody>
<tr>
<td>METAM SODIUM*§</td>
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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.
B. **METAM POTASSIUM**§
   (K-Pam) Label rates See label NA

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NA Not applicable

Text updated: 3/19
Treatment table updated: 3/19
Silver Scurf

*Helminthosporium solani*

**Symptoms and Signs**

Symptoms of silver scurf usually appear on the stem end of tubers as small light brown or grayish leathery spots and may enlarge to cover all of the tuber surface. Lesions have a shiny appearance that is more pronounced when tubers are wet. Margins of young lesions are frequently dark brown and sooty from spore production. Microscopic examination reveals tiny "Christmastree-like" spore structures formed by the production of conidiophores with conidia (spores) attached.

Black dot tuber lesions have a similar appearance but do not have dark, sooty margins and usually contain numerous tiny black dots (sclerotia) that have small microscopic spines. The two diseases can be present on the same tuber. Silver scurf is most noticeable on red-skinned and other smooth-skinned cultivars but can cause substantial damage on russet cultivars. Smooth skin cultivars can be severely infected and rendered unsalable at harvest whereas all cultivars can be substantially damaged during storage. Affected tubers are more susceptible to decay and shrinkage from water loss during storage.

**Comments on the Disease**

The fungus that causes silver scurf, *Helminthosporium solani*, survives on infected seed tubers and on plant debris in infested soil from the previous potato crop. Spores are produced in lesions that develop on infected seed pieces and spread the disease to daughter tubers. New tubers also can be infected by spores present in infested soil.

*Helminthosporium solani* infects tubers through lenticels or directly through the skin and remains confined to the periderm and outer layers of cortex cells. The incidence and severity of the disease increase over time if tubers are left in infested soil. Once tubers are placed into storage, silver scurf lesions can continue to develop, and secondary spread of the disease via spores moved in the air to other tubes in storage can continue when temperatures are above 37°F and humidity is above 90%. Disease incidence increases the longer tubers are held in storage. With time, all tubers within a storage can be severely infected by this pathogen.

If early generation seed tubers are held in common storage with later-generation seed tubers, silver scurf may spread to the early generation from the later generation, which is more likely to have some disease present. Likewise, if multiple lots of potatoes are placed into common storage, a lot infected with silver scurf will produce spores that move through the air system, infecting other lots.
Management

To minimize silver scurf, plant certified seed tubers free of the disease and use seed treatments known to be effective against the silver scurf pathogen. Seed can be assayed before planting to assess silver scurf levels. Harvest as soon as tubers have matured after vinekill. Daughter tubers can also be assayed for silver scurf prior to harvest to help determine risk of damage in storage and determine which lots should be used first. Use humidified airflow to remove free moisture from wet tubers as quickly as possible, and keep storage temperatures as low as possible. The silver scurf pathogen does not survive long periods in the soil so practice a crop rotation of at least two to three years out of potatoes.

Thoroughly clean and disinfect storages before storing a new crop. Do not store early generation seed tubers in the same storage as later-generation seed tubers. Do not repeatedly enter storages over a long period of time and do not begin to remove tubers without completely emptying the storage. Activity in storages encourages the release of spores into the air system and increases levels of silver scurf, particularly if new infections are given enough time to develop.

Post-harvest fungicides are specific to a particular organism or class of organisms and typically applied as a low-pressure spray as potatoes are being conveyed into storage. On the contrary, disinfectants are general biocides with a wide spectrum against both bacteria and fungi which usually applied through the humidification system during the storage season.

The use of chemicals in the air system of storages has not been proven to reduce losses to silver scurf.

<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>SEED TREATMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. FLUDIOXONIL/MANCOZEB (Maxim MZ)</td>
<td>0.5 lb / 100 lb of seed pieces</td>
<td>24</td>
<td>NA</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): PhenylPyrroles (12)/ Dithiocarbamates (M03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. AZOXYSTROBIN (Quadris)</td>
<td>0.4floo–0.8floo/1000 row feet</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): Quinone outside inhibitor (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| <strong>POSTHARVEST TREATMENT</strong> | | |
| A. AZOXYSTROBIN / FLUDIOXONIL / DIFENOCONAZOLE (Stadium) | 1.0 fl oz / 2000 lb of tubers | NA | NA |
| MODE-OF-ACTION GROUP NAME (NUMBER1): Quinone outside inhibitors (11)/ PhenylPyrroles (12)/ DeMethylation inhibitors (3) |
| B. PHOSPHITES (Phostrol) | 0.1 gallon / ton of tubers | 4 | NA |</p>
<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>MODE-OF-ACTION GROUP NAME (NUMBER1): Phosphonates (33)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Spray volume of 0.5 gallon per ton of tubers.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. CLOVE OIL (Biox-C)#</td>
<td>See label</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>MODE-OF-ACTION GROUP NAME (NUMBER1): Plant extract (46)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Biox-C is intended for application as an aerosol through Forced Air Distribution Systems. Although research has shown some efficacy with this fungicide, disease reduction has not been substantial and may not warrant the cost of application.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. AZOXYSTROBIN (Quadris)</td>
<td>0.4–0.8 fl oz / 1000 row feet</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td><strong>MODE-OF-ACTION GROUP NAME (NUMBER1): Quinone outside inhibitor (11)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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

# Acceptable for use on organically grown produce.

NA Not applicable

Text updated: 3/19
Treatment table updated: 3/19
Stem and Stolon Canker (Black Scurf)

*Rhizoctonia solani*

**Symptoms and Signs**

Aboveground symptoms of stem canker include uneven stands, weak shoot growth, and **aerial tubers**. Foliage may develop yellowing, purpling, and upward curling of leaves. Aboveground symptoms alone are not diagnostic, however, because other diseases can cause similar symptoms. On belowground stems and stolons, *Rhizoctonia solani* typically causes **reddish-brown lesions** that often develop into sunken cankers. Stolons can be girdled and killed, resulting in a **pruning effect** and malformation and abortion of tubers. If tubers in affected fields are left in the ground after vine death, they often develop **black scurf**, an accumulation of irregular black sclerotia of *R. solani* on the tuber surface. This is especially visible on fresh market red and white-skinned varieties and is an economically important problem for organic growers.

**Comments on the Disease**

The strain of *R. solani* that typically affects potatoes, called AG-3, is specific for potatoes and generally does not cause damage in or reproduce on other species. Close relatives of potato, such as black nightshade and tomato, may be exceptions. *Rhizoctonia solani* is a soilborne fungus, but inoculum of the fungus on seed tubers (visible as dark, irregularly shaped sclerotia) is sometimes more important for disease development than inoculum in soil. In Kern County, AG-3 types of *R. solani* apparently do not survive in soil between crops of potatoes; whereas in Tulelake districts, *R. solani* AG-3 may overwinter in soil. The fungus only infects juvenile tissue. Disease development is favored by relatively wet, cool (55° to 60°F) soils.

**Management**

Where *R. solani* AG-3 survives in soil between potato crops, rotate out of potatoes for two to three years to reduce soilborne inoculum. Sugarbeet, however, has been associated with increased severity of stem canker in subsequent potato crops.

Reduce initial inoculum by using certified seed tubers that are free from sclerotia of the fungus.

Fungicide treatment of seed tubers can reduce *R. solani* inoculum borne on the seed pieces. The significance of this benefit may be small in fields where heavy soil infestations of *R. solani* AG-3 persist between potato crops.

*Rhizoctonia* stem canker can be further reduced by favoring rapid emergence, such as warming seed tubers before planting, planting tubers at a relatively shallow depth, avoiding early planting dates when soil temperatures are cool and avoid overwatering.
Apply fungicides to seed pieces and/or in-furrow at planting to reduce the disease incidence on belowground stems and stolons. Research indicates that fungicide applications after planting can reduce tuber blemish on daughter tubers. Daughter tubers may also be protected by harvesting quickly after vine desiccation rather than holding tubers in soil for extended periods. However, this may lead to insufficient skin formation and increases the risk of bruising and skinning problems.

<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. FLUTOLANIL</strong> (Moncut)</td>
<td>0.71–1.1 lbs per acre</td>
<td>12</td>
<td>NA</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER1): Succinate dehydrogenase inhibitors (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: For in-furrow use only. Do not apply through irrigation system. Medium to high risk for resistance development.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. FLUTOLANIL/MANCOZEB</strong> (MonCoat MZ)</td>
<td>0.75–1 lb/100 lb cut seed pieces</td>
<td>24</td>
<td>NA</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER1): Succinate dehydrogenase inhibitors (7) / dithiocarbamates and relatives (M3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. PENTHIOPYRAD</strong> (Vertisan)</td>
<td>0.7–1.6 fl oz/1000 row feet</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>MODE OF ACTION GROUP NAME (NUMBER1): Succinate dehydrogenase inhibitors (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: For in-furrow use and after planting. Medium to high risk for resistance development.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D. FLUDIOXONIL</strong> (Maxim PSP)</td>
<td>0.5 lb/100 lb cut seed pieces</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): Phenylpyrrole (12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E. AZOXYSTROBIN</strong> (Quadris)</td>
<td>0.4–0.8 fl oz/1000 row feet</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): Quinone outside inhibitors (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: For in-furrow use and after planting. High risk for resistance development.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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NA Not applicable

Text updated: 3/19
Treatment table updated: 3/19
Verticillium Wilt

Verticillium dahliae

Symptoms and Signs

Verticillium wilt becomes evident when lower leaves on the vine turn yellow and wither. Symptoms progress upward until the entire plant yellows and wilts. Vascular tissue of stems becomes a light brown, which is best observed near ground level. Some tubers from infected plants may develop a light brown discoloration in the vascular ring near the stem end. Wilt causes early senescence of plants in yield loss in heavily infested fields when susceptible varieties are grown.

Comments on the Disease

The fungus persists in soil for long periods. Infection is favored by cool weather and moist soil, but symptom development is favored by high temperatures since the disease interferes with water transport in the stems.

Management

Careful variety selection is the key management tool for this disease. When resistant cultivars are chosen yield loss rarely occurs. Russet Norkotah is a very susceptible cultivar. Yield loss up to 25% can occur when choosing a susceptible variety.

Rotating out of potatoes and other susceptible crops can reduce inoculum and subsequent plant infection (the longer the rotation, the better, no less than 3 years). Crop rotation is not a curative disease management option because the host range of Verticillium is very wide and microsclerotium persist in the soil for a long time. Cereals, corn, and sorghum are good rotation crops. Avoid pepper, tomato, eggplant, and strawberry.

Treatment is rarely required for Verticillium wilt in California areas outside the Klamath Basin. In the Klamath Basin, where susceptible varieties are grown, fumigation with metam sodium can be cost effective, especially when inoculum levels are high. High levels of lesion nematode are known to exacerbate the disease and fumigation with 1,3-dichloropropene* has been shown to decrease disease severity when lesion nematode is present.

<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>METAM SODIUM*§</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.
<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>(Vapam, Sectagon)</td>
<td>37.5–75 gal</td>
<td>See label</td>
<td>NA</td>
</tr>
</tbody>
</table>

**B. 1,3-DICHLOROPROPENE**

(Telone II) Label rates See label NA

**COMMENTS:** Does not target Verticillium wilt, but indirectly lessens its severity by reducing lesion nematodes, which can exacerbate the disease. Only use if lesion nematodes present along with Verticillium wilt.

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

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

NA Not applicable

Text updated: 3/19

Treatment table updated: 3/19
White Mold

*Sclerotinia sclerotiorum*

**Symptoms and Signs**

White mold appears as water-soaked lesions covered by a white, cottony mycelial mat on lower leaves and stems. In severely affected plants, the stem is girdled and plants die. Hard, black, irregularly shaped *sclerotia* (about 0.25–0.5 inch in diameter) develop inside dying potato stems associated with girdling cankers.

**Comments on the Disease**

The fungus overwinters as sclerotia in the soil. When exposed to moisture for prolonged periods, sclerotia germinate and grow into mushroomlike bodies that eject airborne spores, which may infect nearby plants. Petals of flowering potatoes are particularly susceptible and when the petals fall and are associated with lower stems, infection results. Spores can also germinate and infect leaves or stems when free moisture is present for at least 48 hours. Cool temperatures (60° to 70°F) and high relative humidity (95–100%) favor rapid disease development. White mold is most serious in the Klamath-Tule Lake Basin area on late maturing, large vine-type cultivars. *Sclerotinia sclerotiorum* has a wide host range, attacking many broadleaf crops and weeds.

**Management**

Watch for disease symptoms during routine field monitoring, and keep records of your results (example form—PDF). After vine closure, apply water less often so plant surfaces do not remain wet continuously for periods of 48 hours or longer. In between crops, if appropriate, flood soils for 3 to 6 weeks to kill sclerotia. Avoid excess nitrogen, which promotes heavy canopy growth and conditions favorable for the development of white mold. Grow early maturing varieties. Varieties with excessive vine growth can be more prone to the disease. For best results in the Tule Lake region avoid overwatering and prolonged leaf wetness. Time the first fungicide application when plants are in full bloom and follow with a second application 14 days later.

<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>BOSCALID (Endura)</td>
<td>5.5–10 fl oz</td>
<td>12</td>
<td>10</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. BOSCALID (Endura) 5.5–10 fl oz 12 10

MODE OF ACTION GROUP NAME (NUMBER1): Succinate dehydrogenase inhibitors (7)
<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>B. PENTHIOPYRAD</strong> (Vertisan)</td>
<td>14–24 fl oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): succinate dehydrogenase inhibitors (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: For in-furrow use and after planting. Medium to high risk for resistance development.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. FLUOPYRAM</strong> (Luna Tranquility)</td>
<td>11.2 fl oz (ground or chemigation)</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): Succinate dehydrogenase inhibitors (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D. FLUAZINAM</strong> (Omega 500F)</td>
<td>5.5–8 fl oz</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NAME (NUMBER1): 29</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Important Links**

- [Surveying foliage pests form](#) (PDF)

Text updated: 3/19
Treatment table updated: 3/19
Nematodes

Columbia root-knot nematode: *Meloidogyne chitwoodi* (Race 1 & 2)

Lesion nematode: *Pratylenchus penetrans* and *P. neglectus*

Northern root-knot nematode: *Meloidogyne hapla*

Southern root-knot nematode: *Meloidogyne incognita*

Stubby root nematode: *Paratrichodorus* spp.

Description of the Pest

Plant parasitic nematodes are microscopic roundworms that feed on plant roots. They live in soil and plant tissues, and more than one species may occur in a field. They have a wide host range, and vary in their environmental requirements, the symptoms they cause, and the risk to potatoes.

Damage

Overwintering root-knot nematode juveniles invade roots and later tubers, establish feeding sites, and develop into the adult stage. Adult females are swollen, sedentary, and lay eggs in a gelatinous matrix on or just below the root surface. Second-stage juveniles (J2) hatch from these eggs and move through the soil to invade other roots and tubers. When no crop is present, the nematodes survive as eggs or J2, which can be found in the soil. Root-knot nematode feeding reduces the vigor of plants and causes blemishes on tubers. The latter can lead to a severe reduction in tuber quality and, as a result, affected potatoes become unmarketable. Lesion nematodes damage roots by feeding and moving through cortical tissues. In addition, *Pratylenchus penetrans* increases the susceptibility of potato plants to Verticillium wilt and blemishes tubers. *Pratylenchus neglectus* is common in potato fields but has not been shown to damage potatoes in California. Stubby root nematodes feed on root surfaces and can result in formation of numerous stubby roots. Yield loss has not been reported. The major problem caused by this nematode species is transmission of tobacco rattle virus, which causes corky ringspot disease on developing tubers.

Symptoms

The symptoms described below are indicative of a nematode problem but are not diagnostic because they could result from other causes as well. In general, aboveground symptoms include stunted, yellowed, chlorotic, and/or dead plants. Infected plants are
likely to wilt earlier under temperature or moisture stress. Infestations may occur without causing any aboveground symptoms.

Feeding by root-knot nematode causes characteristic swellings, called galls, on roots. Galls caused by *Meloidogyne chitwoodi* are small and difficult to see. On heavily infested plants, egg masses appear as *tiny round bumps* on feeder roots. *Meloidogyne hapla* causes small distinct galls with proliferation of lateral roots around these galls. *Meloidogyne incognita* causes more pronounced galls. All three species of *Meloidogyne* and *Pratylenchus penetrans* cause bumps, warts, or crosslike fissures on the surface of infected tubers. However, those caused by *M. hapla* are less distinct. *Brown spots* develop inside tubers, mostly in the outer 0.25 inch (6 mm), which are visible when a thin layer of tuber is peeled off. Lesion nematodes cause reddish brown lesions on the roots that turn black later. Stubby root nematodes cause numerous short and stunted (stubby) roots, and corky ringspot symptoms on tubers if the nematode is carrying TRV.

**Field Evaluation**

To make management decisions, it is important to know the nematode species present and their population estimates. If a previous crop had problems caused by nematodes that are also listed as pests of potato, their numbers may be high enough to cause damage to subsequent potato crops. Soil samples should be sent to a diagnostic laboratory for enumeration and identification.

Take soil samples in fall from within the root zone of the previous crop after harvest or, preferably, just before harvest. Divide the field into sampling blocks of not more than five acres. Each block should be representative of the field’s cropping history, crop injury, or soil texture. Take several subsamples randomly from a block, mix them thoroughly and make a composite sample of about 1 quart (1 liter) for each block. (See UC ANR Publication 3316, *Integrated Pest Management for Potatoes*, for more details.) Place the samples in separate plastic bags, seal them, and place a label on the outside with your name, address, location, and the current/previous crop and the crop you intend to grow. Keep samples cool (do not freeze), and transport them as soon as possible to a diagnostic laboratory. Contact your farm advisor to help you find a laboratory for extracting and identifying nematodes, and for help in interpreting sample results.

**Management**

*Meloidogyne chitwoodi*, Columbia root-knot nematode, has caused significant crop damage in high organic matter soils at low densities in Modoc and Siskiyou counties. In fields where this root-knot nematode is a problem, long-term integrated management tactics such as crop rotation, cultural controls, fumigation, and nematicides are necessary to prevent a substantial devaluation of the crop due to nematode-induced tuber blemishes.

Fumigants (metam sodium and 1,3-dichloropropene) and non-fumigant nematicides (ethoprop and oxamyl) are chemical control options for minimizing Columbia root-knot
nematode crop damage in soils with low organic matter content. However, in silty clay loam soil with high organic matter when Columbia root-knot numbers exceed 500 second stage juveniles (J2) per 1000cc of soil, neither 1,3-dichloropropene nor metam sodium provide acceptable levels of control.

The following management tactics for Columbia root-knot nematode may increase efficacy in high organic matter soils):

- A combination of fumigation (1,3-dichloropropene) and application of non-fumigant nematicide (oxamyl) can be effective. However, using this combination has not been tested in Californian in high organic matter soils.
- Metam sodium broadcasted and immediately incorporated using a rotary tiller. (Based on one year of research.)
- Multiple depth injection of 1, 3-dichloropropene or metam sodium

For other nematode species there are no precise guidelines for economic threshold levels under California cropping conditions. Fields infested with stubby root nematodes and tobacco rattle virus have been found in Monterey and Kern counties and in the Santa Maria area of Santa Barbara County. Fields with known virus infestations should not be planted to potatoes without an effective control strategy in place for stubby root nematode, which can transmit the virus that causes corky ringspot in potato.

**Prevention**

The following measures will help prevent spread of nematodes to uninfested fields: (1) using certified planting material; (2) cleaning soil from equipment before moving between fields; (3) keeping irrigation water in a holding pond so that any nematodes present can settle out and pumping water from near the surface of the pond; (4) preventing/ reducing animal movement from infested to uninfested fields; and (5) composting manure to kill any nematodes that might be present before applying it to fields.

**Crop Rotation**

Crop rotation can be useful in reducing nematode numbers except of stubby root nematode and the tobacco rattle virus which have wide host range and so crop rotation is not practical. Alfalfa is not a host of *M. chitwoodi*, Race 1; cereals are nonhosts of *M. hapla*; and there are several nematode resistant tomato varieties that can be used if *M. incognita* is a problem. Research in the Pacific Northwest has shown that cover crops of rapeseed, mustard, oilseed radish, or sudangrass reduce numbers of root-knot nematodes when incorporated as green manure. At present there are no nematode resistant potato varieties available. For managing Columbia root-knot nematode, consult the **UC Nematology website**.

**Cultural Control**

Fields that are left fallow but kept weed-free usually have an 80 to 90% per year reduction in root-knot nematode populations. Infested tubers left in the field after
harvest can be a source of inoculum. Destroy potato plants that subsequently emerge from these tubers to restrict nematode reproduction. Avoid storage of tubers infected by *M. chitwoodi* as blemishes can increase during storage.

<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 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. **METAM SODIUM**

(Vapam HL)

37.5–75 gal

See label

NA

COMMENTS: Contact your farm advisor for advice on the most effective application method for a particular situation. Fumigants such as metam sodium and 1,3-dichloropropene are a prime source of volatile organic compounds (VOCs), which are a major air quality issue.

B. **ETHOPROP**

(Mocap EC)

Maximum label rate

See label

NA

COMMENTS: Contact your farm advisor for information on maximizing the effectiveness of this material.

C. **1,3–DICHLOROPROPENE**

(Telone II)

Label rates

See label

NA

COMMENTS: Helps to control lesion nematode, which is associated with Verticillium wilt and stubby root nematode, which is associated with corky ringspot. Fumigants such as metam sodium and 1,3-dichloropropene are a prime source of volatile organic compounds (VOCs), which are a major air quality issue.

D. **OXAMYL**

(Vydate C-LV)

Label rates

48

7

MODE OF ACTION GROUP NAME NUMBER1): 1A

‡ 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 elapsed before harvest.

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

NA Not applicable

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

Text updated: 8/19

Treatment table updated: 8/19
# Weeds

## Common and Scientific Names of Weeds

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>barnyardgrass</td>
<td>Echinochloa crus-galli</td>
</tr>
<tr>
<td>bermudagrass</td>
<td>Cynodon dactylon</td>
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<tr>
<td>bindweed, field</td>
<td>Convolvulus arvensis</td>
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<td>bluegrass, annual</td>
<td>Poa annua</td>
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<td>buckwheat, wild</td>
<td>Polygonum convolvulus</td>
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<tr>
<td>cudweeds</td>
<td>Gnaphalium spp.</td>
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<tr>
<td>dodders</td>
<td>Cuscuta spp.</td>
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<td>fiddleneck, coast</td>
<td>Amsinckia menziesii var. intermedia</td>
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<td>foxtails</td>
<td>Setaria spp.</td>
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<tr>
<td>johnsongrass</td>
<td>Sorghum halepense</td>
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<tr>
<td>knotweed, common</td>
<td>Polygonum arenastrum</td>
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<tr>
<td>lambsquarters, common</td>
<td>Chenopodium album</td>
</tr>
<tr>
<td>mustards</td>
<td>Brassica spp.</td>
</tr>
<tr>
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<td>Urtica urens</td>
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<tr>
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<td>Solanum nigrum</td>
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<tr>
<td>nightshade, hairy</td>
<td>Solanum physalifolium</td>
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<td>Cyperus rotundus</td>
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<td>nutsedge, yellow</td>
<td>Cyperus esculentus</td>
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<td>Avena fatua</td>
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<td>Amaranthus spp.</td>
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<td>shepherd's-purse</td>
<td>Capsella bursa-pastoris</td>
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<td>Cirsium arvense</td>
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<tr>
<td>thistle, Russian</td>
<td>Salsola tragus</td>
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<tr>
<td>witchgrass</td>
<td>Panicum capillare</td>
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Text updated: 08/19
Integrated Weed Management

An effective weed management program takes into account the type of weeds present, crop rotation, cultivation, available herbicides, and the competitive ability of the potato crop. Competition from early season weeds will reduce yields if they are not controlled within 4 to 6 weeks after potatoes emerge. Weeds that emerge after vines have covered the rows usually will not compete with the potato crop; however, they may reduce yields by interfering with harvest and can produce seed that will cause infestation of subsequent crops. Weeds frequently become more serious if crop growth is delayed by adverse conditions early in the season. Weed problems can be reduced by establishing a vigorous stand of potatoes.

Weeds and potato management vary in the two major potato-growing regions of California: Kern County and the Tule Lake region. In the Kern County region, soils are sandy or sandy loam with organic matter levels below 1%. Plantings are made from late November until early March for the spring and summer crop and in July for the much smaller acreage winter crop. In the Tule Lake region, soils are largely silty clay loams with organic matter levels of 3 to 15%; plantings are made in May and are harvested in fall. Consequently, not only do cultural practices vary in the two regions but weed species and herbicide usage as well.

Monitoring

To plan a weed management program, you must know what kinds of weeds are present, which ones are most abundant, and whether their abundance is changing. Regularly survey each field to determine which weed species are present and the effectiveness of previous weed control measures. During the early part of the potato season, especially before row closure, make weekly surveys. Pay special attention to perennials and, where they occur, dodder infestations. Also be sure to record annual weeds that have produced seed. Where potatoes are in the crop rotation, note weeds in the previous crops as well.

To survey the weeds, randomly walk through the field and rate the degree of infestation for each weed species. Sketch a map of the field and mark where perennials occur. Maps are very useful for rechecking the same areas each season to determine if special controls are needed during fallow or rotational crops. This information will become increasingly valuable over the years in predicting weed problems. Record weed survey information (example form—PDF).

Weed Management

Some potato varieties are competitive with weeds and can be grown without herbicides if conditions, such as soil moisture, are conducive to weed emergence before the potatoes. Most weeds can then be removed by a cultivation that is timed just before potato emergence. A few weeds, however, such as nutsedges and nightshades, emerge with and after the potatoes and are best controlled with crop rotation or herbicides.
The competitive ability of the potato plant varies considerably among the different varieties. If you want to grow potatoes without herbicides, choose one of the more competitive varieties. White Rose, Ute russets, Chieftain, and Red LaSoda are very aggressive and cover rows quickly. The new Russet Norkotah tends to be a bit more upright and varies in cover, while the Tejon White is somewhat less aggressive. Sometimes disease, lack of nitrogen, air pollution, or climatic changes can alter how these varieties grow. Varieties that are harvested green for chipping have less problems with weeds, including nutsedges, invading after early season cultivation because the vine canopy remains until harvest.

Crop rotation and cultivation can both be used effectively to manage weeds. Crop rotation is useful in controlling difficult weed problems because it allows for a greater variety of weed control methods. Cultivation can also greatly reduce weed populations if already emerged.

Herbicides are a principal component in most potato weed control programs. Herbicide choice depends not only on present weed species, but on soil type, cultural practices, potato cultivar herbicide tolerance, and herbicide availability. In many fields two or three herbicide applications may be needed during the potato growing season. Use herbicides that will control the weed species in your field with the appropriate application method, rate, and timing, and if possible, kill weeds before they grow beyond the seedling stage.

When carefully used, herbicides labeled for use in potatoes grown in California control most annuals that presently infest potato fields, as well as some perennial weeds such as nutsedge, johnsongrass and bermudagrass. There are herbicides which are soil-active only (will not control emerged weeds), foliar-active only (will not control weeds which have not emerged) and herbicides that have both soil and foliar activity. Depending upon the label and the weeds, herbicides can be applied preplant; after planting, preemergence to weeds or potatoes or both; or postemergence to potatoes and weeds.

When soil-applied, preplant or layby herbicide applications are used on high organic matter soils, elevated rates may be required for acceptable weed control. Carefully follow all herbicide label recommendations for use rates on various soil types.

In some areas, vine-kill or desiccants are applied in preparation for harvest. These are usually contact, postemergence (foliar) herbicides. In case of field-stored potatoes, roll dead vines to break the stems of tall weeds and compress soil to prevent soil cracking. Use postemergence herbicides if additional weed control is necessary.

**Weed Management Before Planting**

**Crop Rotation**

Cereals, including small grains, corn, and milo (sorghum), are valuable in rotation; herbicides that cannot be used in potatoes can be used for controlling problem weeds in these crops and after their harvest. Perennial weeds can also be controlled after a grain harvest by discing and watering to encourage weed growth in fall and then applying a
postemergence, translocated herbicide to the growing weeds. Dry or irrigated fallowing after May/June harvests in Kern County permits control of many weeds. Crop rotations also can help to control disease and nematodes.

Alfalfa is a good rotation crop on marginal soils that will not support potato production in short rotations. Alfalfa shades out many annual weeds and repeated mowing of alfalfa rids the field of emerged weeds before they produce seed and helps reduce infestations of some troublesome weeds. However, alfalfa is susceptible to some root-knot nematode species which may diminish the crop’s usefulness in a potato rotation. Other crops closely related to potatoes, such as tomato, pepper, and eggplant are not good rotation crops because the available herbicides are similar to those used in potato. Other than an increase in the weed species not controlled by these herbicides, this fact may not allow for effective herbicide mode of action rotation to prevent or delay herbicide resistance development.

**Cultivation**

Potato fields should always be tilled after previous crops are harvested to reduce weed seed or propagule production. Further tillage should be done if weeds grow and approach their reproduction stages before potatoes are planted.

**Herbicides**

A preplant herbicide is used during field preparation or fertilizer application before planting potatoes. Preplant, soil-active herbicides usually are incorporated into the soil mechanically or with sprinkler irrigation before weeds emerge in order to kill germinating weed seeds or just as weed seedlings are emerging. Nonselective foliar-active herbicides such as paraquat and glyphosate also can be applied before planting to control emerged weeds.

For nutsedge control in Kern County, the soil-active herbicide EPTC should be applied by March 1. It may be applied preplant or postplant, but two or three applications a season are usually necessary. Metribuzin can be used in Siskiyou and Modoc County. Trifluralin and EPTC or Pendimethalin and EPTC are often used as preemergent weed control tank-mixes.

**Weed Management After Planting**

Depending on the type of irrigation system used, potato fields can be cultivated at several periods before the canopy closes over the rows to manage most weeds.

In Kern County, timing the plantings to take advantage of the considerable competitive nature of potatoes is a most beneficial method. On spring potatoes planted in winter, rows can be cultivated during the winter, just before potato emergence until the plants are 4- to 8-inch tall, if necessary. This removes winter weeds and often the first flush of spring weeds. On February plantings, a cultivation during the period just before emergence to the 4- to 8-inch stage, is usually adequate for season long control of most
annual weeds because the potato plants grow so rapidly and outcompete most weeds, with the exception of nutsedges. In summer plantings, the intense heat favors rapid weed growth. Cultivate when weeds are small. Multiple cultivations are sometimes needed to control multiple weed flushes. Delay irrigation after cultivation as long as possible to prevent re-rooting and new weed germination.

In areas where potatoes are irrigated with solid set sprinklers, most growers are reluctant to cultivate after potatoes have significant shoot and root development due to the risk of root pruning and physical damage to shoots. Untimely hot spell can severely reduce yields or quality if solid set sprinklers are broken apart to permit cultivation and not put back together quickly to resume irrigation. Potatoes should be kept on the wet side of moist; they transpire a lot of water in hot weather from their rather limited root system. If used, cultivations should be very shallow and done about 3 to 5 days following irrigation. Another concern with tillage is the problem of soil compaction.

In the Tule Lake region, well-timed cultivations can greatly reduce the need for chemical control. Postplant hilling cultivations can eliminate weeds already emerged. However, in order to be effective, cultivation should occur when these weeds are less than 1 inch tall, enough soil is thrown over the weeds to kill them, and weeds which lay on top of the soil are allowed to dry out and die. Later emerging weed seedlings can be controlled by a second cultivation or by postemergence, foliar-active herbicides. A second cultivation before the row closes over may even eliminate the need for chemical weed control. If postemergence chemical weed control is still required, early cultivation will reduce early weed pressures as well as the size of the weeds needing to be controlled. To maximize weed control effectiveness and to minimize compaction, cultivate when soils are relatively dry. Fields just cultivated should not be irrigated for at least 24 hours to allow for complete desiccation of the uprooted weeds.

**Herbicides**

Depending on the weeds present, preemergence herbicides applied after potato planting also may be needed in addition to the preplant application. After planting, a combination of two or three preemergence herbicides is applied during or just after hilling. Cultivation just prior to preemergence herbicide application can kill weeds already-emerged. If additional control is necessary after potatoes emerge, certain herbicides may be applied through sprinkler irrigation (chemigation). Postemergence, foliar-active herbicides are sprayed onto emerged weeds, most effectively while they are small and actively growing.

Preemergence herbicides are normally applied during the first three weeks after planting and are incorporated into the soil using sprinkler irrigation or mechanically during cultivation and hilling. Application after the last cultivation is usually preferred to prevent disturbing herbicide-treated soil in the row. Soil-active, preemergence herbicides safe to emerged potatoes and applied two to three weeks after planting extend residual control. In this scenario, postemergence, foliar-active herbicides should be included in the tank-mix if emerged weeds are present.
Nonselective postemergence herbicides such as paraquat, glyphosate, or carfentrazone can be applied after planting but before crop emergence or crop injury will occur. Rimsulfuron and metribuzin have both soil and foliar activity and so they can be applied alone or in combination before or after weed or potato emergence. Rimsulfuron is also often split-applied before and after potato emergence or twice postemergence. Read variety fact sheets before using metribuzin as potato varieties vary in their tolerance to this herbicide. Selective postemergence grass herbicides such as clethodim or sethoxydim can be applied to control grass weeds.

Killing potato vines before natural senescence can aid in tuber maturity and skin-set and also kill some weed species still green in the field, but the benefits from vine killing are largely dependent on variety. Flail mowing, rolling, and chemical desiccation are the three traditional methods for vine killing. Mowing and desiccation help prevent weeds from interfering with mechanical harvest. They also may aid in preventing weed maturity and seed production.

In Tule Lake and other potato regions with high organic matter content soils, s-metolachlor (Dual Magnum II) can be applied to the soil surface before potato emergence for control of nightshade, yellow nutsedge, and other weeds. It is preferable to incorporate s-metolachlor by sprinkler irrigation, but it also can be incorporated by shallow tillage after planting. Dimethenamid-p and pendimethalin can also be applied preemergence on high organic matter soils present in the Tule Lake area. In such case, use the high rate of dimethenamid-p; application must be followed by rainfall, irrigation or shallow mechanical incorporation. Where soils have more than 0.5% organic matter, a postemergence metribuzin application or metribuzin and rimsulfuron combination may be used to control emerged broadleaf weeds. For best results, apply herbicides when weeds are small, less than 1 inch tall. Metribuzin is not recommended on some sensitive potato varieties, which includes early-season white-skinned and most red-skinned varieties.

If using EPTC in Kern County and an application has already been made preplant, another (sequential) application can be made after planting with rolling cultivators and incorporation into the beds, or by chemigation through solid set sprinklers after the beds are cultivated and shaped. Since this herbicide is volatile, follow the label carefully for incorporation timing. Results are sometimes erratic, especially when rain does not occur, and irrigations are not made soon enough after application to activate it before weeds emerge.

Pendimethalin or trifluralin usually are not needed if EPTC is used sequentially. Pendimethalin is often used postplant with EPTC to suppress nightshade. Pendimethalin applied at low label rates then sprinkler-incorporated before potatoes emerge effectively controls several weed species including pigweeds, lambsquarters, nightshades, and mustards with reasonable crop safety. On high organic matter soils, control may only be partial. A tank mix of pendimethalin and dimethenamid-p can also be beneficial and often provides better control than either product alone. Note that dimethenamid-p must be applied as preemergence to the potatoes. When pendimethalin is applied after potato emergence, the risk of crop injury increases; do not use after potatoes reach 6 inches in height. In varieties that have less top growth,
adding a low rate of pendimethalin to the postplant application of EPTC enhances late season grass and pigweed control. On winter plantings, emerged nettle and winter mustards can be controlled with paraquat before potatoes emerge.

**Weed Management at Harvest**

In areas where potatoes are grown for early harvest, weed numbers in subsequent years may be reduced with weed control at this time since they are destroyed before their seeds mature. Alternately, after the vines and weeds have been shredded, a 2- to 6-inch soil mound can be created over the beds to help maintain soil moisture around the potatoes during the skin-set period. At the same time, weed germination is prevented because the surface soil is dry.

**Herbicides**

At harvest, rolled beds can be treated with paraquat or diquat for potato vine kill and to kill nutseedge and other weed foliage to stop further growth immediately. Diquat can be very effective. For vigorous potato varieties that often have late-season growth, two applications, spaced one week apart, may be necessary. Follow the label for correct rates. Burning with propane is sometimes used for vine kill, more to prevent early blight tuber infections and facilitate rapid mechanical harvest than for weed control. It can desiccate weeds with one pass over, but a second pass is required to ignite the weed vegetation. Do not use glyphosate!

Normally desiccants are not needed in Kern County, especially on chipping varieties; the vines desiccate when irrigation is discontinued. Diquat and glufosinate can be used for vine kill for stored and seed potatoes. Stem end browning caused by the use of desiccants is a concern of growers but rarely occurs in California.

Text updated: 08/19
Special Weed Problems

NIGHTSHADE

The best strategy for controlling nightshade species (hairy, black, and cutleaf nightshade) is to plan a crop rotation sequence that prevents population build-up. Choose rotation crops, such as corn, sorghum, cereals, or sugar beets, which can be managed with herbicides that kill nightshades. Nightshades are prolific seed producers; once a nightshade numbers increase, it may take several rotations to reduce infestations significantly. Tillage, a combination of two or three different herbicides effective on nightshades and multiple herbicide applications may be necessary to control nightshade infestations in potatoes. Dimethanamid-p, flumioxazin, and rimsulfuron are herbicides that have been shown to be effective at controlling hairy and black nightshade.

NUTSEDGE

Yellow nutsedge is very serious problem in the Kern County area and must be carefully managed at harvest since nutsedge rhizomes can reduce potato quality by penetrating tubers. This weed does not tolerate shade; once potato vines have closed over, further nutsedge emergence and growth is usually suppressed. In early-season potato areas, herbicides may not be necessary if the potato canopy closes over the row before nutsedges begin to emerge. In fields where nutsedges will most likely emerge before row closure, plant to use a preemergence application of EPTC before March 1; if necessary and allowed by label, apply EPTC again after approximately 1 month. In regions with high organic matter content soils, apply s-metolachlor to the soil surface and incorporate before potato emergence.

Before harvest, thoroughly apply vine-killing agents to suppress nutsedge growth after vine death and to help prevent tuber damage. Several herbicides can be used to control or suppress nutsedge in rotation crops; some very effective herbicides are available for grains or alfalfa. It is most likely not possible to eradicate nutsedge, however, even when weed control is used during fallow periods.

QUACKGRASS

Quackgrass is a problem in the northern California potato-growing areas. Its rhizomes may penetrate potato tubers, reducing their quality. Quackgrass growth can be suppressed for one growing season and rhizomes reduced, but not eradicated, with a preplant EPTC application. The area to be treated must be tilled thoroughly to cut quackgrass rhizomes into small pieces before applying the herbicide. Incorporate the EPTC into the soil by discing 6 inches (15 cm) deep in two directions. Fall treatments with EPTC may provide additional control.

Before potatoes are planted, glyphosate can be used to control actively growing quackgrass that is at least 8 to 10 inches tall. For complete control, repeated applications may be necessary. Wait at least 5 to 7 days after the last application before preparing seedbeds. After planting, if quackgrass is a problem, clethodim or sethoxydim may be used. Sequential treatments may be necessary.
# Susceptibility of Weeds to Herbicide Control

<table>
<thead>
<tr>
<th>ANNUAL WEEDS</th>
<th>CAR</th>
<th>CLE</th>
<th>DIME</th>
<th>EPT</th>
<th>GLY</th>
<th>MCH</th>
<th>MET</th>
<th>PAR</th>
<th>PEN</th>
<th>RIM</th>
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<tbody>
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<tr>
<td>shepherd’s-purse</td>
<td>P N — C C C P C C N — N N</td>
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<tr>
<td>smartweed, pale</td>
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<tr>
<td>thistle, Russian</td>
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<td>witchgrass</td>
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<td>PERENNIAL WEEDS</td>
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<tr>
<td>bermudagrass</td>
<td>N P — N — C N N N N N N P N</td>
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<tr>
<td>bindweed, field (seedling)</td>
<td>P N — N N C N N P P P N P N</td>
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<tr>
<td>bindweed, field (perennial)</td>
<td>C N N N N P N N N N N P N</td>
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<tr>
<td>johnsongrass</td>
<td>N C — N C — N N N N P C N</td>
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<tr>
<td>nutsedge, purple</td>
<td>N N — C N N C N N P N — N N</td>
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<tr>
<td>nutsedge, yellow</td>
<td>N N P C — C C P N N — N N</td>
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<tr>
<td>quackgrass</td>
<td>— C — C — C C P N N P N C N</td>
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<tr>
<td>thistle, Canada</td>
<td>— N N N N N P N N N N N</td>
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</tr>
</tbody>
</table>

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

CAR = carfentrazone (Shark)      MET = metribuzin (Sencor)
CLE = clethodim (Intensity)      PAR = paraquat* (Gramoxone)
DIM = dimethenamid (Outlook)      PEN = pendimethalin (Prowl)
EPT = EPTC (Eptam)      RIM = rimsulfuron (Matrix)
FLM = flumioxazin (Tuscany)      SET = sethoxydim (Poast)
GLY = glyphosate (Roundup)      TRI = trifluralin (Treflan)
MCH = s-metolachlor (Dual Magnum II)

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

Text updated: 08/19
# Herbicide Treatment Table

<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>Carfentrazone</strong> <em>(Shark EW)</em></td>
<td>0.181 lb a.i./season</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td><strong>Trifluralin</strong> <em>(Treflan HFP)</em></td>
<td>0.375 lb a.i.</td>
<td>12</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Dimethenamid-P</strong> <em>(Outlook)</em></td>
<td>0.5625–0.6562 lb a.i. coarse soils (&lt;3% OM)</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>0.6562–0.8437 lb a.i. coarse soils (&gt;3% OM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.6562–0.8437 lb a.i. medium/fine-textured soils (&lt;3% OM)</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>0.8437–0.9843 lb a.i. medium/fine-textured soils (&gt;3% OM)</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td><strong>Eptc</strong> <em>(Eptam 7E)</em></td>
<td>3.06–5.25 lb a.i.</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td><strong>Flumioxazin</strong> <em>(Tuscany SC)</em></td>
<td>0.748 oz a.i.</td>
<td>12</td>
<td>NA</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 Herbicide Susceptibility Table for information on specific weed control. Always read the label of the product being used.

**ONLY PREPLANT OR FALLOW**

**A. Carfentrazone** *(Shark EW)*

WSSA MODE-OF-ACTION GROUP NUMBER: 14

**COMMENTS:** Apply before planting potatoes.

**B. Trifluralin** *(Treflan HFP)*

WSSA MODE-OF-ACTION GROUP NUMBER: 3

**COMMENTS:** Apply preplant only tank-mixed with EPTC. Incorporate 2 to 3 inches into the soil, no later than 24 hours after application. Not effective on emerged weeds.

**PREPLANT AND POSTPLANT**

*Before the weeds emerge*

**A. Dimethenamid-P**

WSSA MODE OF ACTION GROUP NUMBER: 15

**COMMENTS:** Apply preemergence following planting or after drag off. Preplant applications can be impregnated on dry bulk fertilizer. Broadcast uniformly followed by rainfall, sprinkler irrigation or shallow mechanical incorporation. On muck and high organic matter soils use the highest rate (0.9843 lb a.i./acre). Do not apply after potato emergence. Not effective on emerged weeds. Can be tank mixed with other preemergence products.

**B. Eptc** *(Eptam 7E)*

WSSA MODE OF ACTION GROUP NUMBER: 8

**Apply and immediately incorporate just before planting; or apply after planting potatoes as a direct spray to the soil and incorporate before crop emerges, using rolling cultivators (Lilliston types). Will provide some suppression of hairy nightshade but will not control it on soils exceeding 10% organic matter. May be applied again at layby. Meter into the sprinklers before weeds emerge (about 30 days after the previous application). Do not exceed 14 pt Eptam 7EC per acre per crop. In Lassen, Modoc, Shasta and Siskiyou counties, up to 6 lb a.i./acre per application may be used. Can be tank mixed with other preemergence products. Not effective on emerged weeds.*

**C. Flumioxazin** *(Tuscany SC)*

WSSA MODE-OF-ACTION GROUP NUMBER: 14
### COMMENTS

Apply after hilling, but before potatoes emerge, otherwise crop injury may occur, because vegetative parts are sensitive. Apply and incorporate when at least 2 inches of soil cover potato sprouts. Ground, chemigation, or aerial application. Do not apply to poorly drained, cool, or wet soil. Can be tank mixed with other preemergence products.

### D. METRIBUZIN

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>REI‡</th>
<th>PHI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>(TriCor DF)</td>
<td>0.250–0.499 lb a.i.</td>
<td>12</td>
<td>60</td>
</tr>
</tbody>
</table>

**WSSA MODE-OF-ACTION GROUP NUMBER: 1, 5**

**COMMENTS:** Pre-plant incorporated broadcast spray or impregnated on dry fertilizer. **Do not use on Centennial, Shepody or other sensitive varieties.** Do not use TriCor DF on potatoes in Kern County, California. Can be tank mixed with other preemergence products. Do not apply after potato emergence.

### E. PENDIMETHALIN

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>REI‡</th>
<th>PHI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Prowl H2O)</td>
<td>0.7125 lb a.i. coarse soil</td>
<td>NA</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>0.95 lb a.i. medium-textured soil (&lt; 3% OM)</td>
<td>24</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>1.425 lb a.i. medium-textured soil (&gt; 3% OM)</td>
<td>NA</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>1.425 lb a.i. fine-textured soils</td>
<td>NA</td>
<td>24</td>
</tr>
</tbody>
</table>

**WSSA MODE-OF-ACTION GROUP NUMBER: 1, 3**

**COMMENTS:** Do not use on muck or peat soils. Works best preemergence on weeds, but somewhat less safe for crop. For annual weeds, apply and soil incorporate into planted beds before potato emergence, or apply preemergence at slightly lower than label rates and sprinkle within 7 days for annual weeds. Do not apply after potatoes are 6 inches tall. Can be tank mixed with other preemergence products. Not effective on emerged weeds.

### F. RIMSULFURON

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>REI‡</th>
<th>PHI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Matrix SG)</td>
<td>0.25–0.37 oz a.i.</td>
<td>4</td>
<td>60</td>
</tr>
</tbody>
</table>

**WSSA MODE-OF-ACTION GROUP NUMBER: 1, 2**

**COMMENTS:** For grasses. If treatment for broadleaf weeds is planned, do not apply broadleaf application within 1 day of grass treatment, because grass control may be diminished. No fewer than 7 days between cultivation and application. **Not effective on weeds which have not emerged.**

### G. s-METOLACHLOR

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>REI‡</th>
<th>PHI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Dual II Magnum)</td>
<td>0.955–1.91 lb a.i.</td>
<td>24</td>
<td>60</td>
</tr>
</tbody>
</table>

**WSSA MODE-OF-ACTION GROUP NUMBER: 1, 15**

**COMMENTS:** Apply preemergence and sprinkle or incorporate shallowly after hilling. Use lower rate on relatively coarse-textured soil or soil low in organic matter. Use the higher rate on fine-textured soils or soils high in organic matter. Do not use on muck or peat soils. Do not harvest within 60 days after the at-planting to drag-off application. Can be tank mixed with other preemergence products. Not effective on emerged weeds.

### After the weeds emerge

### A. CLETHODIM

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>REI‡</th>
<th>PHI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intensity)</td>
<td>0.093–0.25 lb a.i.</td>
<td>24</td>
<td>30</td>
</tr>
</tbody>
</table>

**WSSA MODE-OF-ACTION GROUP NUMBER: 1**

**COMMENTS:** For grasses. If treatment for broadleaf weeds is planned, do not apply broadleaf application within 1 day of grass treatment, because grass control may be diminished. No fewer than 7 days between cultivation and application. **Not effective on weeds which have not emerged.**
<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>B. GLYPHOSATE</td>
<td>0.38–1.1 lb a.i.</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>(Roundup)</td>
<td>0.55–1.6 pts</td>
<td></td>
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</tr>
<tr>
<td>WSSA MODE OF ACTION GROUP NUMBER‡:</td>
<td>9</td>
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</tr>
<tr>
<td>COMMENTS: Apply low rates before potato emergence. Avoid contact of spray with the foliage or green stems of potatoes. Do not irrigate for 6 hours after application. For perennial weeds, apply appropriate rate for each weed, usually without a surfactant. Treatments in late summer and fall are best when weeds have been irrigated and are growing well. Not effective on weeds which have not emerged.</td>
<td></td>
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</tr>
<tr>
<td>C. METRIBUZIN</td>
<td>0.25 lb–0.499 lb a.i. redroot pigweed/lambsquarters</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>(Tricor DF)</td>
<td>0.499 lb a.i. others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER‡:</td>
<td>5</td>
<td></td>
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<tr>
<td>COMMENTS: Rate can be split between 2 applications, 14 days apart, or split between pre- and postemergence application. Apply before weeds are more than 1 inch tall. Let at least 24 hours pass before other pesticides are used. Do not use on Atlantic, Centennial, Chipbelle, Shepody or other sensitive varieties. Crop injury may occur if postemergence applications are followed by cool, cloudy weather. For use in Modoc and Siskiyou counties only.</td>
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<tr>
<td>D. PARAQUAT*</td>
<td>0.345–0.69 lb a.i.</td>
<td>24</td>
<td>NA</td>
</tr>
<tr>
<td>(Gramoxone SL 2.0)</td>
<td>1–2 pt</td>
<td></td>
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</tr>
<tr>
<td>WSSA MODE OF ACTION GROUP NUMBER‡:</td>
<td>22</td>
<td></td>
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</tr>
<tr>
<td>COMMENTS: Delay application as long as possible but apply before potatoes emerge. No more than three applications per year. Apply before potato emergence with a nonionic surfactant. Do not use on muck or peat soils to avoid injury to subsequent crops. For use on emerged annual weeds.</td>
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</tr>
<tr>
<td>E. RIMSULFURON</td>
<td>0.25–0.37 oz a.i.</td>
<td>4</td>
<td>60</td>
</tr>
<tr>
<td>(Matrix SG)</td>
<td>1.0–1.5 oz</td>
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<tr>
<td>WSSA MODE OF ACTION GROUP NUMBER‡:</td>
<td>2</td>
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</tr>
<tr>
<td>COMMENTS: Apply when weeds are small (&lt; 1 inch high or across). Rate can be split into two postemergence applications or into one pre-and one postemergence spray. The second application can be applied between 14 to 28 days after the first. For activation, supply moisture by rainfall or sprinkler (0.25–0.75 inch) no later than 1 week, but no sooner than 4 hours after application. Use a nonionic surfactant with at least 80% active ingredient at 0.125–0.25% v/v. Temporary chlorosis may occur if crop is under stress. Check label for plant back restrictions.</td>
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<tr>
<td>F. SETHOXYDIM</td>
<td>0.28 lb a.i.</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>(Poast Herbicide)</td>
<td>1.5 pts</td>
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<td></td>
</tr>
<tr>
<td>WSSA MODE OF ACTION GROUP NUMBER‡:</td>
<td>1</td>
<td></td>
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<tr>
<td>COMMENTS: Do not cultivate within 5 days before applying or within 7 days following application. Use a nonphytotoxic oil concentrate in the spray tank. For annual or perennial grasses.</td>
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</tbody>
</table>

**HARVEST-BURN DOWN**

| A. PARAQUAT* | 0.345–0.69 lb a.i. | 24           | NA          |
| (Gramoxone SL 2.0) | 1–2 pt        |              |             |
| WSSA MODE OF ACTION GROUP NUMBER‡: | 22           |              |             |
| COMMENTS: Do not use to desiccate potato vines when potatoes are to be stored or used for seed. Do not exceed 3 pt/acre per season. Use with a nonionic surfactant. |

**HARVEST - VINE DESSICATION**

<p>| A. DIQUAT | 0.46–0.93 lb a.i. | 24           | 7           |
| (Reglone Desiccant) | 1–2 pt   |              |             |</p>
<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
<th>REI‡</th>
<th>PHI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(hours)</td>
<td>(days)</td>
</tr>
<tr>
<td>WSSA MODE-OF-ACTION GROUP NUMBER‡: 22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. GLUFOSINATE (Rely 280)</td>
<td>0.3839 lb a.i. + 21 fl oz</td>
<td>12</td>
<td>9</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.

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

NA Not applicable

1 Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode of action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see http://www.plantprotection.org/HRAC/.

Treatment table updated: 08/19
Text updated: 08/19
Vertebrates
Managing Vertebrates

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 reinvasde if the field is adjacent to rangeland, waterways, or unmanaged areas. It is much easier to manage vertebrate pests by implementing controls 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 reinvasion 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>Measures</th>
<th>Frightening</th>
<th>Shooting</th>
<th>Fumigating</th>
<th>Repellents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deer</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Eastern fox squirrel</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>California ground squirrel</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pocket gophers</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rabbits</td>
<td></td>
<td>X</td>
<td>X^2</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Rats</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voles</td>
<td></td>
<td>X</td>
<td></td>
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1During hunting season or with a permit.

2Cottontails are relatively easy to trap. Jackrabbits are difficult to trap, but trapping may be useful.

3Not 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 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. 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.
For more information on vertebrate management, see the *Vertebrate Pest Control Handbook*.

Text updated: 07/16
**Voles (Meadow Mice)**

**Identification**

Six species of voles, genus *Microtus*, occur in California. The most widespread species in the state is the California vole (*Microtus californicus*), which occurs in the Central Valley and throughout the length of the coast range. Most damage to potatoes occurs in the Klamath Basin, where the montane vole (*M. montanus*) is found.

Voles are 4 to 6 inches long when full grown, with a blunt nose, small eyes, and short, furry ears. The tail is less than half as long as the body and is slightly hairy. Voles are active day and night, and may be seen scurrying around aboveground although usually they are hidden in vegetation. The clearest indication that voles are present is the network of aboveground runways that connect burrow openings that are about 1.5 to 2 inches in diameter. **Droppings** are about 0.18 inch (4.5 mm) long and greenish when fresh, turning brown or gray with exposure to the environment. Sometimes fresh leaves or other cuttings are found in these trails.

**Biology and Behavior**

Voles, also called meadow mice or field mice, live in colonies in areas such as irrigated pastures, fence-rows, or weedy ditchbanks, where the soil is suitable for burrowing and where vegetation provides cover. They usually avoid the sandy soils in which potatoes are commonly grown. The soil of the Tule Lake Basin of northern California is more favorable for voles, and there is also abundant natural habitat where vole populations can remain active year-round. In this area vole populations reach levels that require control every 7 to 10 years. Controls are required less frequently in other parts of the Klamath Basin.

**Damage**

Voles move into potato fields when infested grain or alfalfa fields are harvested, usually in August or September, burrowing into hills for shelter and to feed on tubers. Their feeding damages tubers directly and their burrows may expose tubers to sunlight or freezing temperatures, causing additional losses. Damaged tubers have **gnaw marks** about 0.12 inch (3mm) wide and 0.36 inch (9 mm) long at various angles. Damage may also be caused by predators that dig into potato hills in search of voles. If vole populations are high at harvest, they may be carried into storage, where they will continue to feed on tubers and also contaminate the crop.

**Management**

In the Tule Lake Basin, ditchbanks are monitored with visual inspection and traps to determine the relative numbers and presence of voles each spring by the county agricultural commissioners' offices. Visual inspections take into consideration the density of the vole population, cluster size, and distribution over the assessed area.
Inspections at 30-day intervals provide information on the movement and magnitude of change of the populations.

If monitoring programs in your area indicate that voles may become serious, begin checking your fields for vole activity when removing irrigation pipe at the end of the season or after nearby grain or alfalfa fields are harvested. Look for active burrows—ones with fresh soil around the entrance. Check closely around clumps of wild oats, where vole burrows are most likely to be found. A trap index of 6 to 10 or more mice per 100 trap nights is indication of a pending problem and is, therefore, often used as a threshold for initiating vole control.

When trap monitoring or visual estimates of vole activity indicate damage is likely, poison bait may be applied to ditchbanks in spring to slow or prevent the population from expanding into the crop. (Bait can legally only be applied directly to potato fields after vine death.)

In other Klamath Basin growing areas, there are no regular monitoring programs because voles rarely reach damaging levels. However, a routine check for vole activity near the end of each season is a good way to identify if voles may become a problem during the next growing season. If you find vole activity in your fields at the end of the season, check with your farm advisor or agricultural commissioner's office to see if bait application is recommended.

Text updated: 7/16
More Information

- Herbicide resistance: Glyphosate
- Herbicide Symptoms Photo Repository website and tool
- *Integrated Pest Management for Potatoes*, UC ANR Publication 3316
- Mitigating pesticide hazards
- UC Vegetable Research and Information Center
- UC Weed Research and Information Center
- Year-round IPM programs video