UC IPM
Pest Management Guidelines:
ALFALFA

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Authors

Insects and Mites: L. D. Godfrey, Entomology, UC Davis; E. T. Natwick, UCCE Imperial Co.; P. B. Goodell, UC IPM Program and Kearney Agricultural Research and Extension Center; R. F. Long, UCCE Yolo Co.; V. M. Barlow, UCCE Riverside Co. and UC IPM Program; I. M. Grettenberger, Entomology, UC Davis; M. Leinfelder-Miles, UCCE San Joaquin Co.; M. D. Rethwisch, UCCE Riverside Co. (Blythe)

Diseases: R. M. Davis, Plant Pathology, UC Davis (Emeritus); C. A. Frate, UCCE Tulare Co. (Emeritus); D. H. Putnam, Plant Sciences, UC Davis

Nematodes: B. B. Westerdahl, Nematology, UC Davis; P. B. Goodell, UC IPM Program and Kearney Agricultural Research and Extension Center, Parlier; R. F. Long, UCCE Yolo Co.

Weed Management: W. M. Canevari, UCCE San Joaquin Co. (Emeritus); T. J. Getts, UCCE Lassen Co.; S. B. Orloff, UCCE Siskiyou Co.; D. H. Putnam, Plant Sciences, UC Davis; R. G. Wilson, Intermountain REC

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

Crop Leadership Team: R. F. Long, UCCE Yolo Co. (crop team leader); P. B. Goodell, UC IPM Program and Kearney Agricultural Research and Extension Center (IPM facilitator); R. DeBiase, UC IPM Program (coordinator); R. Baldwin, Wildlife, Fish and Conservation Biology, UC Davis; C. A. Frate, UCCE Tulare Co.; L. D. Godfrey, Entomology, UC Davis; S. B. Orloff, UCCE Siskiyou Co.

ACKNOWLEDGMENT FOR CONTRIBUTIONS

Insects and Mites: D. R. Haviland, UCCE Kern Co; C. G. Summers, Entomology, Kearney Agricultural Research and Extension Center

Nematodes: S. Hafez, Univ. Idaho, Parma, ID; U. C. Kodira, Nematology, UC Davis

Weeds: C. E. Bell, UCCE San Diego Co. (Emeritus); W. T. Lanini, Weed Science and Plant Sciences, UC Davis (Emeritus); R. F. Norris, Vegetable Crops and Weed Science, UC Davis (Emeritus); J. L. Schmierer, UCCE Colusa Co. (Emeritus); R. N. Vargas, UCCE Madera Co. (Emeritus); R. G. Wilson, Intermountain Research & Extension Center

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Produced and edited by:
UC Statewide IPM Program
University of California Agriculture and Natural Resources
Guidelines Coordinator: R. DeBiase, P. Kosina, C. Reynolds (vertebrates)
Production: F. Rosa

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- University of California
  ANR Communication Services
  2801 Second Street, Davis, CA 95618-7779
  530-750-1213; 800-994-8849

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

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

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To be used with UC ANR Publication 3312, *Integrated Pest Management for Alfalfa Hay*

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Alfalfa Year-Round IPM Program (Reviewed 3/17)

ANNUAL CHECKLIST

Supplement to UC IPM Pest Management Guidelines: Alfalfa

Use these guidelines for a monitoring-based IPM program to effectively manage pests, while reducing the risks of pesticides on the environment and human health.

When a pesticide application is considered, review the Pesticide Application Checklist for information on how to minimize the risks of pesticide use to water and air quality. Water quality can be impaired when pesticides drift 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 program covers the major pests of planting and establishing a stand of alfalfa hay in California. For established stands of alfalfa hay, see Established Stands. Details on carrying out each practice and information on additional pests, are available from the UC IPM Pest Management Guidelines: Alfalfa. Color photo identification sheets and examples of monitoring forms can be found at the forms and photo identification pages.

Stand establishment is the most critical single factor affecting successful IPM strategies in alfalfa. Follow the practices in the Year-Round IPM Program to establish and maintain a healthy vigorous stand that resists pest problems.

PLANTING TO STAND ESTABLISHMENT

✓ Done	**Preplant** **Special issues of concern related to water quality:** drift, runoff due to rain.
	Select your field, considering: • Pest history, especially weeds. • Current crops and pest problems. • Surrounding crops and vegetation. • Presence of Sclerotinia stem and crown rot (white mold) on site or in neighboring alfalfa fields. • Soil conditions, particularly salinity and proper drainage for disease management.
	Manage weeds with herbicides or cultivation prior to planting if necessary.
	Consider crop rotation to minimize weeds, diseases, and nematodes.
	Prepare the field for planting by: • Deep tilling to assure deep rooting patterns and drainage • Leveling the land if flood irrigating • Creating a firm but loose seedbed for seed germination Take into account the potential for drainage and run-off problems.
	Consider planting alfalfa on shallow beds (24–60-inch wide and 4–8 inch deep furrows) on heavy soil types. The beds allow water movement off crowns, helping to prevent seedling diseases
	Select varieties that are tolerant or resistant to known problem pests.
	Select seed considering: • Use of certified seed (weed- and stem nematode-free) • Seed treatment for suspected field pathogens or if planting at suboptimal time. • *Rhizobium* treatment for nitrogen fixation if alfalfa has not recently been grown in the field; it is good to inoculate all fields, as it is cheap insurance. • Select varieties with genetic resistance to major diseases and pests known to occur in the region

✓ Done	**Stand establishment** **Special issues of concern related to water quality:** drift, runoff due to rain, irrigation.
	Ensure proper stand establishment to reduce weed and disease pressure. Plant seed, using proper timing, depth, and seedling rates.

✓ Done	**Stand establishment** **Special issues of concern related to water quality:** drift, runoff due to rain, irrigation.
	• Plant at the proper time for each region: o Central Valley: early fall (September through October) o Imperial Valley: October o Intermountain: spring or August • Plant ¼ to ½ inch deep, depending on soil type. • Assure proper seed-soil contact by using press wheels or rollers. • Provide timely irrigation for seedling germination; do not overirrigate. • Use a higher seed rate for organic production. For more information, see Irrigated Alfalfa Management for Mediterranean and Desert Zones, UC ANR Publication 3512.
	Consider interplanting a low density of oats in organic alfalfa or where soil erosion occurs to reduce weed competition and soil erosion, but manage carefully to avoid competition and alfalfa stand loss. • For more information, see *Overseeding and companion cropping in alfalfa*, UC ANR Publication 21594.
	Survey weeds when the crop germinates. • Keep records on a weed survey form (PDF). • Apply a postemergence herbicide, if needed according to the Pest Management Guidelines.
	Watch for seedling pests. **Invertebrates** • Aphids • Crickets • Cutworms • Flea beetles • Garden symphylans • Grasshoppers • Sowbugs • Thrips • Wireworms **Diseases** • Damping-off diseases such as *Pythium*, *Phytophthora*, and *Rhizoctonia* • Downy mildew • Sclerotinia stem and crown rot (white mold) Keep records on a map of the field (PDF). Manage if needed according to the Pest Management Guidelines.
	Monitor newly-established fields for gopher, meadow vole, and ground squirrel infestations Manage, if needed, according to the Pest Management Guidelines.

✓ Done	**Growth to first cutting** **Special issues of concern related to water quality:** drift, runoff due to rain, irrigation.
	Look for signs of weevils, such as chewed leaves. • Manage if needed according to the Pest Management Guidelines.
	Monitor aphids and their natural enemies. • Keep records on an aphid monitoring form (PDF). • Manage if needed according to the Pest Management Guidelines.
	Monitor soil moisture regularly.
	Survey weeds to plan weed management strategy. • Keep records on a weed survey form (PDF). • Apply a postemergence herbicide, if needed according to the Pest Management Guidelines.
	Time first cutting carefully to maintain stand vigor. • Make sure rooting depth is at least 12–18 inches and the crown is formed. • Generally, delayed first cuttings are recommended to assure proper rooting depth. • Check soil moisture status, considering compaction by heavy equipment; high moisture conditions can compact soils.
	Identify other diseases you may see. • Common leaf spot and other leafspot diseases • Downy mildew

✓ Done	**Growth to first cutting** **Special issues of concern related to water quality:** drift, runoff due to rain, irrigation.
	• Sclerotinia stem and crown rot (white mold)

ESTABLISHED STANDS - INTRODUCTION

✓ Done	**Winter** **Special issues of concern related to water quality:** drift, runoff due to rain.
	Survey winter weeds in December through January. • Keep records on a winter weed survey form (PDF).
	Determine weed management strategy based on last year's weed types and abundance. Consider: • Applying pre- or postemergence herbicide. • Overseeding with grasses or legumes. • Grazing or cultivating with a spring-toothed harrow, taking care to minimize damage to the alfalfa crowns.
	Note any special weed problems such as dodder and perennial weeds. Manage, if needed, according to the Pest Management Guidelines.
	Begin to monitor for aphids in January.
	Monitor for weevils: • Look for chewed leaves, especially on stands putting on new growth, and take sweep-net samples when alfalfa height allows. • Keep records on a weevil monitoring form (PDF). • Manage if needed according to the Pest Management Guidelines.
	Look for signs of vertebrate pests. such as gophers, meadow voles, or ground squirrels. • Manage, if needed, according to the Pest Management Guidelines.
	Scout for signs of stem nematode (generally from December through March or April).

✓ Done	**Spring** **Special issues of concern related to water quality: runoff due to rain, irrigation, or drift**

	Time harvests by considering:
	• Alfalfa growth, vigor and quality
	• Pest problems including:
	  ○ Aphids
	  ○ Leaf and stem diseases
	  ○ Weevils
	• Irrigation and wheel traffic
	Consider border-strip harvesting to conserve natural enemies.

	Determine appropriate weed management strategies based on last summer's weed species and numbers. Note any special weed problems< such as: • Dodder • Grasses • Nutsedge Manage if needed according to the Pest Management Guidelines.
	Look for signs of vertebrate pests, such as gophers, meadow voles, or ground squirrels. Manage, if needed, according to the Pest Management Guidelines.
	Look for signs of stem nematode in early spring. • Prevent the spread of nematodes by cutting fields first or cleaning harvesting equipment between infected and clean fields.

✓ Done	**Spring** **Special issues of concern related to water quality: runoff due to rain, irrigation, or drift**
	Monitor for weevils. Consider early harvest if Egyptian alfalfa weevil is a problem in your field. • Keep records on a weevil monitoring form (PDF). • Manage if needed according to the Pest Management Guidelines.
	Monitor aphids and their natural enemies. • Consider border or strip harvest to preserve natural enemies. • Keep records on an aphid monitoring form (PDF). • Manage if needed according to the Pest Management Guidelines.
	Look for cutworms if damage is apparent. • Manage if needed according to the Pest Management Guidelines.
	If you see thrips or evidence of thrips feeding, no pesticide application is needed.
	Watch for signs of diseases and nematodes.
	Consider field sanitation: • Harvest disease- and stem nematode-free fields before infested fields. • Avoid moving contaminated farm machinery or livestock from a field infested with nematodes or disease to a clean field. • Be careful when using return water because pathogens and nematodes can be carried in recirculated irrigation water.

✓ Done	**Summer** **Special issues of concern related to water quality: drift, runoff due to irrigation.**
	Time harvests by considering: • Alfalfa yield, quality, and stand persistence. Early harvests result in poor stand persistence, encouraging weeds. • Pest problems • Irrigation and wheel traffic • Alfalfa market and price differential for different quality grades
	Survey weeds, especially weedy grasses. • Keep records on a weed survey form (PDF) for next spring's weed management decisions.
	Monitor cowpea and spotted alfalfa aphids. • Consider border or strip harvest to preserve natural enemies. • Keep records on a monitoring form. • Manage if needed according to the Pest Management Guidelines.
	Monitor caterpillars and armyworms. Consider early harvest to reduce losses. • Keep records on a caterpillar monitoring form. • Manage if needed according to the Pest Management Guidelines.
	Monitor leafhoppers at the first sign of damage. Consider early harvest to reduce losses. • Keep records on a monitoring form. • Manage if needed according to the Pest Management Guidelines.
	Look for cutworms if damage is apparent. Manage if needed according to the Pest Management Guidelines.
	Watch for signs of diseases and disorders(such as nutrient deficiencies, yellowing due to anoxia, or abiotic factors like scald).
	Keep records of other invertebrates.
	Look for signs of vertebrate pests, such as gophers, meadow voles, or ground squirrels. Manage if needed according to the Pest Management Guidelines.
	Use proper field sanitation: • Harvest disease- and stem nematode-free fields before infested fields.

✓ Done	**Summer** **Special issues of concern related to water quality: drift, runoff due to irrigation.**
	• Avoid moving contaminated farm machinery or livestock from a field infested with stem nematodes or disease to a clean field. • Be careful when using return water because pathogens and nematodes can be carried in recirculated irrigation water.
	Manage irrigation water to prevent standing water, which can kill alfalfa plants through scald, especially at the tail-ends of fields. If possible, avoid watering on hot days (above 104ºF), but if unavoidable: avoid standing water in fields for over 8 hours.

✓ Done	**Fall** **Special issues of concern related to water quality: drift, runoff due to rain, irrigation.**
	Time harvests by evaluating pest problems, irrigation, and weather.
	Survey weeds just after the alfalfa is cut. • Keep records on a monitoring form. • Plan on late fall through winter weed management strategies.
	Monitor aphids. and their natural enemies • Keep records on a monitoring form. • Manage if needed according to the Pest Management Guidelines.
	Monitor caterpillars. Consider early harvest to reduce losses. • Keep records on a monitoring form. • Manage if needed according to the Pest Management Guidelines.
	Consider field sanitation: • Harvest disease- and stem nematode-free fields before infested fields. • Avoid moving contaminated farm machinery or livestock from a field infested with stem nematodes or disease to a clean field. • Be careful when using return water because pathogens and nematodes can be carried in recirculated irrigation water.
	Look for signs of vertebrates such as gophers, meadow voles, or ground squirrels. • Manage if needed according to the Pest Management Guidelines

✓ Done	**Pesticide application checklist**
	When planning for possible pesticide applications in an IPM program, consult the Pest Management Guidelines, and review and complete this checklist to consider practices that minimize environmental and efficacy problems.
	✓ Choose a pesticide from the Pest Management Guidelines for the target pest, considering:
	• Impact on natural enemies and pollinators. For more information see Protecting Natural Enemies and Pollinators at http://ipm.ucanr.edu/mitigation/protect_beneficials.html.
	• Potential for water quality problems using the UC IPM WaterTox database. See http://ipm.ucanr.edu/TOX/simplewatertox.html.
	• Impact on aquatic invertebrates. For more information, see *Pesticide Choice*, UC ANR Publication 8161 (PDF), http://anrcatalog.ucanr.edu/pdf/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), http://anrcatalog.ucanr.edu/pdf/8012.pdf.
	• Endangered species that may be near your site. Find out using the Department of Pesticide Regulation's PRESCRIBE program. (http://cdpr.ca.gov/docs/endspec/prescint.htm)
	✓ Before an application

✓ Done	Pesticide application checklist
	• Ensure that spray equipment is properly calibrated to deliver the desired pesticide amount for optimal coverage. (See http://ipm.ucanr.edu/training/incorporating-calibration.html)
	• 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 or over 10 mph
	  • Temperature inversions
	  • Just prior to rain or irrigation (unless it is an appropriate amount, such as when incorporating a soil-applied pesticide)
	  • At tractor speeds over 2 mph

	• Avoid spraying areas of bare soil, such as weevil-damaged areas, with pesticides prone to cause water quality problems. Consider overseeding these areas with grasses.
	• Identify and take special care to protect sensitive areas (for example, waterways or riparian areas) surrounding your application site.
	• Review and follow labeling for pesticide handling, personal protection equipment (PPE) requirements, storage, and disposal.
	• Check and follow restricted entry intervals (REI) and preharvest intervals (PHI).
	✓ After an application
	• Record application date, product used, rate, and location of application.
	• Follow up to confirm that the pesticide application was effective.
	✓ Consider water management practices that reduce pesticide movement off-site.
	• Consult relevant publications, such as *Protecting Surface Water from Sediment-Associated Pesticides in Furrow-Irrigated Crops*, UC ANR Publication 8403 (PDF), http://anrcatalog.ucanr.edu/pdf/8403.pdf.
	• Consult the Department of Pesticide Regulation Groundwater Protection Program (GWPA) website for pesticide information and mitigation measures. (http://cdpr.ca.gov)
	• Install an irrigation recirculation or storage and reuse system.
	• Consider alternative water application methods such as sprinklers and drip irrigation which limit off-site water movement
	• Limit irrigation to amount required using soil moisture monitoring and evapotranspiration (ET). (See *Irrigated Alfalfa Management for Mediterranean and Desert Zones: Irrigating Alfalfa in Arid Regions*, UC ANR Publication 8293 (PDF), http://anrcatalog.ucanr.edu/pdf/8293.pdf.)
	• Consider vegetative filter strips or ditches. (For more information, see *Vegetative Filter Strips,* UC ANR Publication 8195 (PDF), http://anrcatalog.ucanr.edu/pdf/8195.pdf.)
	• Apply polyacrylamides in bedded alfalfa and drainage ditches to prevent off-site movement of sediments.
	• Redesign inlets and outlets into tailwater ditches to reduce erosion. (For more information, see *Reducing Runoff from Irrigated Lands: Tailwater Return Systems*, http://anrcatalog.ucanr.edu/pdf/8225.pdf)
	✓ Consider practices that reduce air quality problems.
	• When possible, reduce volatile organic compound (VOC) emissions by decreasing the amount of pesticide applied, choosing low-emission management methods, and avoiding fumigants and emulsifiable concentrate (EC) formulations.

For more about mitigating the effects of pesticides, see the Mitigation page: ipm.ucanr.edu/mitigation/.

General Information

(Section reviewed 3/17)

INTEGRATED PEST MANAGEMENT (3/17)

Integrated pest management uses a combination of crop management, careful monitoring of pest populations, and timely control activities to prevent and manage pest outbreaks. Common methods in alfalfa production include biological control by natural enemies, modification of cutting schedules, crop rotation, pest-resistant varieties, and the use of pesticides when needed. Proper stand establishment, irrigation management, and effective crop management are critical to encourage a vigorous alfalfa crop that is better able to withstand weed infestations, insect feeding, and disease incidence.

WEEDS

Weeds are often the most important yield- and quality-reducing pest problem, especially in older stands. An integrated pest management (IPM) program begins with effective weed management during stand establishment, the correct identification of weed species at different times of the year and an effective weed management strategy. Proper stand establishment, harvest timing, crop rotation, and irrigation management all help prevent weed intrusion. Overseeding older depleted stands with other forages (grasses or legumes) can extend stand life and assist in preventing weed infestations. When herbicides are needed, use proper timing to achieve maximum efficacy. In addition, take care to avoid off-site movement of herbicides with irrigation or rain events.

INSECTS

Although alfalfa fields are home to many beneficial insects, there are also several very damaging arthropods as well. The most damaging insects in alfalfa hay in California are

1. Alfalfa weevil (occurs primarily in late winter),
2. Aphid complex (occurs in spring, summer, and fall, depending on species),
3. Summer worm complex (armyworms, alfalfa caterpillars, etc.), and
4. Leafhoppers (can occur at various times).

Proper identification of insect pests and natural enemy species is essential to an IPM program for pest control. Many insect species, particularly in the immature stages, are similar in appearance and may be easily confused. For example, lygus bug nymphs, which are pests of alfalfa seed, may be confused with aphids. Pea aphid and blue alfalfa aphid are similar in appearance and can easily be mistaken for each other. Because economic treatment thresholds are specific for the pest species, proper identification is critical. Likewise, failure to properly identify natural enemy species may lead to unnecessary pesticide applications if predator or parasite numbers are sufficient to maintain pest numbers below economic treatment levels.

DISEASE & NEMATODES

There are very few pesticides for the management of most diseases and none for nematode control in established alfalfa stands. Selection of resistant varieties, irrigation management, soil drainage, crop rotation and prevention of mechanical spread of pests and diseases are important IPM strategies.

USE OF PESTICIDES

When pesticide intervention becomes necessary, follow the label for proper pesticide rate and application method. Choose pesticides that are relatively safe to natural enemy species and honeybees,

while maximizing control of the pest. Selection of a pesticide product for an application depends on several factors including registration status, activity on the pest, preharvest interval (PHI), cost, length of residual control, harm to natural enemies and pollinators, and environmental toxicity hazard. Design herbicide use strategies to prevent weed resistance and shifts in weed species.

Use the online year-round IPM program for guidance in carrying out a comprehensive IPM program for alfalfa hay.

For more information on integrated pest management in alfalfa, see *Irrigated Alfalfa Management for Mediterranean and Desert Zones*, UC ANR Publication 3512 and *Intermountain Alfalfa Management*, UC ANR Publication 3366.

SITE SELECTION TO AVOID PEST PROBLEMS (3/17)

An important IPM strategy is to choose fields that are well suited to alfalfa production. A field's cropping history is important; alfalfa planted in fields with poor drainage, poor nutrient balance, or infested with alfalfa pests, especially weeds, will suffer yield loss and greater pest problems.

Identify the crops and vegetation surrounding your alfalfa fields and determine pest history for those fields. For example, check to see if they harbor pathogens (such as *Sclerotinia*) or have a history of nematodes. Carefully planned cultural practices, including early fall planting dates, can help manage pests, including insects, weeds, and diseases.

KEY ISSUES FOR SITE SELECTION

- **Drainage**
  Proper drainage is critical for the development of a healthy root system. If drainage is poor, consider physical modification such as deep tillage, raised beds, or installation of drainage tiles.
- **Soil type**
  Alfalfa grows successfully on a wide range of soil textures, but sandy loam to clay-loam soils are preferred.
- **Soil depth**
  A site should provide a minimum of 3 feet of unrestricted rooting depth.
- **Water holding capacity**
  High water-holding capacity is desired, but with good drainage.
- **Soil pH, soil fertility**
  Near neutral pH is highly preferred. Low pH soils cause problems with nodulation with *Rhizobium* bacteria and nitrogen fixation, while high pH soils may have limitations for nutrient availability and salinity or sodicity issues. A pH of 6.4 to 7.5 is recommended.
- **Toxic elements**
  Check for excess boron, selenium, or sodium.
- **Water supply, water quality, and irrigation system**
  Sufficient supplies of adequate quality water are required for successful production. Established alfalfa is tolerant of moderately saline water and high nitrate wastewater. Choose an appropriate irrigation system for site (sprinkler, flood or drip).
- **Topography**
  Highly variable fields with high and low spots may require land leveling, depending upon irrigation system.
- **Salinity**
  Alfalfa is somewhat tolerant of saline soils and water, but salinity can reduce stand establishment and growth, and encourage weed intrusion. Alfalfa can tolerate salinity levels up to 5 dS/L, but care should be taken to manage saline soils and water, especially during stand establishment. On very saline soils, mitigate salinity over time by growing other crops (e.g. barley) and leaching salts.
- **Cropping history**
  Do not plant alfalfa after alfalfa; rotate to another crop for at least 1 to 2 years between alfalfa plantings. This is important to manage residual disease, weed, nematode, and rodent problems. Rotate with non-legume crops (i.e., corn, cereals, cotton, tomato).

- **Weed history**
  If high numbers of difficult-to-control weeds are present, avoid the field and develop a strategy for control before planting.
- **Disease history**
  If diseases are known for a region, be sure to select appropriate disease-resistant varieties.
- **Nematode history**
  If field has a history of nematodes that attack alfalfa, select varieties rated as highly resistant, consider crop rotations, or avoid using the field for alfalfa.
- **Insect history**
  If weevils, aphids, cutworms, or armyworms are known for and area, develop an IPM strategy for control.

For more information on site selection, see *Irrigated Alfalfa Management for Mediterranean and Desert Zones,* UC ANR Publication 3512.

SELECTION OF ALFALFA VARIETIES (3/17)

Selection of appropriate varieties is a critical aspect of an IPM program. Of special importance is the disease, insect, and nematode resistance package of a variety, but other factors are important as well. Often, there are few other cost-effective strategies available, especially for root diseases and nematodes. Varieties should be selected for maximum yield, high level of pest resistance within the appropriate fall dormancy classification for a given area.

Table 1. Suggested fall dormancy and minimum pest resistance ratings for alfalfa pests for six California climatic zones

	Fall Dormancy	Bacterial Wilt	Verticillium Wilt	Fusarium Wilt	Anthracnose Race 1	Phytophthora Root Rot	Spotted Alfalfa Aphid	Pea Aphid	Blue Alfalfa Aphid	Stem Nematode	Southern Root Knot Nematode	Northern Root Knot Nematode
Zone	**FD**	**BW**	**VW**	**FW**	**AnTh**	**PRR**	**SAA**	**PA**	**BAA**	**StN**	**SRKN**	**NRKN**
Intermountain	3–5	HR	HR	HR	HR	HR	R	R	R	HR	R	R
Sacramento	4–8	R	R	HR	HR	HR	HR	HR	HR	HR	R	R
San Joaquin Valley	7–9	R	R	HR	HR	HR	HR	HR	HR	HR	HR	HR
Coastal	5–7	HR	HR	HR	HR	HR	MR	HR	HR	HR	HR	HR
High Desert	4–8	HR	HR	HR	HR	HR	R	R	HR	HR	HR	HR
Low Desert	8–11	MR	LR	HR	R	HR	HR	HR	HR	R	HR	HR

Fall Dormancy Rating: Varieties are rated 2–11, with 2 being most dormant during fall period and 11 being least dormant or most winter active in standardized field tests.

Resistance abbreviations: Ratings are based upon the percentage plants in a cultivar population which are resistant in standardized tests: HR=Highly resistant (>51% of population), R=Resistant (31–50% population), MR= Moderately Resistant (15–30% of population), LR= Low Resistance (6–14% of population)

Consult relevant publications for more information on alfalfa varieties:

- For a complete discussion on alfalfa varieties, see *Irrigated Alfalfa Management for Mediterranean and Desert Zones*, UC ANR Publication 3512.
- For currently available resistant varieties, see the list of alfalfa varieties provided by the National Alfalfa & Forage Alliance website.
- For current variety performance data for California, see University of California Alfalfa and Forages website.

CROP ROTATION IMPACTS ON PESTS (4/24)

Crop rotation has the ability to reduce the weeds, diseases, insects, and nematodes that harm alfalfa. Avoid planting alfalfa directly into a field from where an alfalfa crop was recently removed; instead, have at least one or two rotations to a different crop. Rotation to a nonhost crop can significantly reduce pest numbers and types in the field. The table below provides information on nonhost crops that suppress alfalfa-associated pests. Also included is a list of rotation crops that can use herbicides that may not be registered for use in alfalfa.

If your field is infested with stem nematode or pathogens listed in the key below, consider choosing a nonhost crop from the table. A 3- to 4-year nonhost crop rotation is ideal. A rotation of lesser duration is still beneficial, but to a lesser degree.

Rotation crops have different effects on various weed species. Winter weeds can be effectively controlled with small grain plantings accompanied by an appropriate herbicide application. Summer weeds can be controlled by growing a summer annual rotation crop (corn, bean, sunflower, cotton, and tomatoes), and using selective herbicides and cultivation.

Volunteer alfalfa around the field edges of a rotation crop may perpetuate nematode populations. If your field has a history of nematodes, be sure to remove all volunteer alfalfa.

Recommended Rotation Strategies To Control Pests Common To Alfalfa	
Pest	**Rotation Information**
Northern root-knot nematode	2 to 3 year rotation with nonhost crops such as cotton, blackeye cowpeas, and some lima bean varieties
Stem nematode	3 to 4 year rotation with small grains, beans, cotton, corn, sorghum, lettuce, carrots, tomatoes, or forage grasses[1].
Diseases: Anthracnose Bacterial wilt Common leaf spot Spring black stem Stagonospora	3 to 4 year rotation with small grains, beans, corn, sorghum, forage grasses[1].
Winter weeds	A minimum of 1 year (preferably longer) in crops such as small grains (wheat, oats, barley, triticale) or winter forage grasses (e.g. ryegrass) that allow the use of selective herbicides that might not be registered in alfalfa.
Summer weeds	A minimum of 1 year with crops that compete well with summer weeds, such as small grains, beans, cotton, corn, sorghum, or summer forage grasses (e.g. sudangrass or teff grass) and allow the use of selective herbicides that are not registered in alfalfa.
Clover root curculio	A minimum of 1 year rotating out of alfalfa and other legumes because seedling alfalfa roots are weaker and more susceptible to root feeding.
Gophers	At least 3 years rotation to an annual crop along with tillage.
SPECIAL WEEDS	
Dodder	At least 2 years with nonhost crops such as cotton, small grains, beans, corn, sorghum, or forage grasses. Avoid rotations with crops that also serve as a host for this weed (e.g., tomato, onion, and carrot). However, management in season with glyphosate in Roundup Ready alfalfa is highly effective, so a 2-year or longer rotation may not be necessary in this case.
Nutsedge	Two-year rotation with corn or sorghum that includes application of herbicide to control nutsedge. A rotation to Roundup Ready alfalfa that can be managed in season with glyphosate is useful to control yellow nutsedge.

[1] Three- to four-year rotations may give satisfactory results, depending on the severity of the infestation. A rotation for fewer years will give some suppression.

HARVEST SCHEDULING AND HARVEST IMPACTS ON IPM (3/17)

Harvest frequency or scheduling can have major effects on pests, particularly weeds and diseases, but harvests can also be used to mitigate insect infestations. Generally, harvest schedules are dictated by the desire to maximize yield and quality and by practical considerations such as irrigation scheduling, labor, and machinery availability.

In the intermountain regions of California, 3 to 4 harvests are common, 5 to 7 harvests are practiced in the Sacramento valley, 6 to 8 harvests in the San Joaquin Valley, and 8 to 11 harvests in the low deserts of Imperial Valley and Palo Verde Valley. Timings range from a low of 24 days to over 40 days between harvests.

HARVEST CONSIDERATIONS FOR SUCCESSFUL PEST MANAGEMENT

Earlier harvests generally result in higher quality, but lower annual yields and lower stand persistence. This is known as the yield/quality tradeoff. The choice of harvest time represents a compromise between the customer's demand for quality and the grower's desire to maintain high yield and a vigorous stand.

While early harvest results in highly digestible, high protein forage, harvesting after the plant has had the opportunity to replenish root reserves increases yield and significantly improves health. This improves the competitive ability of the alfalfa stand, and the plant's ability to tolerate pests, especially weeds. These benefits of a longer cutting schedule are often carried over from season to season. Decisions involving harvest timing, cutting height, windrow management, wheel compaction by harvesting equipment, and border harvesting can affect pest problems, as well as yield, quality, and profitability.

Staggered Harvest Schedules

Growers have a major incentive to harvest early for high quality forage and higher prices, and sometimes to mitigate insect pests. However, this should be followed by longer cutting schedules to enable root reserves to recover so that long-term productivity is not affected. Therefore, a staggered schedule of long-short intervals is usually recommended, providing some high-quality hay while enabling crop recovery for improved stand persistence.

Effects of Wheel Traffic on Growth, Compaction, Water

There are typically four trips across a field with each harvest (swather, rake, baler and balewagon or accumulator). This can crush new regrowth and cause significant compaction lowering water infiltration and promoting diseases due to a lack of oxygen to the roots. Loss of plant stand due to traffic can be significant enough to allow weed intrusion. Efforts to control traffic (e.g., eliminating the bale collection step by depositing large bales at ends of fields) can help.

Harvesting Early When Pest Numbers Are High

Although this should not be done regularly, an early harvest can quickly reduce the effects of high numbers of insects, making an insecticide spray unnecessary. Early harvest may be a

good strategy to avoid further damage when the alfalfa crop has a late infestation of alfalfa weevil in spring, or caterpillar damage in summer and can help avoid an insecticide spray. After harvest, however, growers need to monitor fields carefully to detect early damage to the young shoots, which can be devastating to regrowth and the following crop.

Watch pest feeding under windrows. Alfalfa weevils, alfalfa caterpillars, armyworms, and cutworms may feed on growth under windrows, so these areas should be monitored carefully.

Fall Harvest Management

Improperly timed fall harvests can result in stand decline and winterkill. Ideally, the last harvest of the season should be early enough to allow plants enough time to build up reserves before the first frost or late enough (weather permitting) that minimal regrowth occurs after the last harvest. The timing of the last harvest is not critical in more southern regions, where frosts are later or nonexistent, but can play a role when using soil residual herbicides for winter weed control. For some of these herbicides, application should occur when plants are dormant (or at least growing slowly), though soil should be exposed to maximize efficacy of the herbicide. If the last cutting is too early, significant growth can occur before it is cold enough to apply the soil residual herbicide and the canopy will interfere with the herbicide reaching the soil.

While a winter canopy helps to suppress winter weeds, during a wet foggy winter, a canopy can enhance conditions that allow Sclerotinia stem and crown rot to develop and spread. Clipping (even late fall clipping) is an important management tool when conditions are right for *Sclerotinia* or where meadow voles are a problem.

Border Strip Harvesting

Border strip harvesting involves leaving uncut strips of alfalfa at various intervals across the field as a refuge for natural enemies. This also retains lygus bug and other pest insects in the alfalfa (where they do no harm), keeping them out of neighboring crops such as cotton or beans where they cause significant damage. Research has shown that this practice significantly increases the numbers of parasitoids and predators of aphids, caterpillars, and other alfalfa insect pests.

Leave 10 to 14 feet wide uncut strips adjacent to every other irrigation border. At the following cutting, uncut strips are left adjacent to the alternate irrigation borders. Care should be taken when in mixing 'old' (e.g. 56 day) and 'new' (28 day) hay since blends of 75/25 new/old alfalfa and 50/50 new/old alfalfa may not qualify as prime feed for lactating dairy cows; such blends are acceptable for use as horse hay, and for beef and dry cows. In addition, uncut strips of alfalfa afford some protection to adjacent crops such as cotton and to a lesser extent dry beans, by providing habitat for lygus bug.

For more complete discussion of harvesting and harvest management, see *Irrigated Alfalfa Management for Mediterranean and Desert Zones*, UC ANR Publication 3512 and *Cutting Schedule Strategies to Maximize Returns*, 36th Western Alfalfa &Forage Symposium.

IRRIGATION MANAGEMENT IMPACTS ON IPM (3/17)

Irrigation management is a major component of an IPM program. Standing water prevents vigorous high-yielding alfalfa growth (alfalfa does not like wet feet). Root diseases and nematode infestations are often the direct result of poor water infiltration or lack of drainage. Irrigation management affects diseases, insects, rodents, and weeds. It can also affect the environment, including natural waterways due to off-site movement of pesticides carried in water or on particulates.

Approximately 82% of California's alfalfa is flood irrigated (check-flood or bedded alfalfa), 15% is sprinkler irrigated (wheel-lines and pivots), and perhaps 2 to 3% is drip irrigated. Each of these systems impact on pest management.

KEY IRRIGATION CONSIDERATIONS

Standing Water and Tail End Crop Damage

Flood-irrigated alfalfa often results in standing water, particularly at the ends of fields. This can kill plants, cause diseases, and result in weed intrusion, particularly water-loving weeds such as nutsedge and summer grasses. Virtually all flood-irrigated fields have some field-end alfalfa damage due largely to standing water. Reduce tail-water damage with better system design (slope, drain design), automated methods of water shutoff, and drainage ditches to reduce tail-water effect. Be careful when using return water because pathogens and nematodes can be carried in recirculated irrigation water.

Scald

Scald is plant death due to standing water in flood-irrigated systems under high temperatures (e.g., over 104º F). Since respiration continues at high temperatures, and oxygen is displaced by water, the plant suffocates and dies. If possible, only irrigate during cool periods or at night, or reduce the irrigation run length in flood systems so the water moves more quickly across fields.

Offsite Pesticide Movement

Pesticides, particularly organophosphates, can move in solution with irrigation water. Minimize irrigation runoff to protect water quality. Methods to prevent off-site tailwater impacts include: tail-water return systems, managing irrigation water carefully to minimize runoff, and improved irrigation methods such as drip irrigation. For more information on reducing offsite pesticide movement, *Controlling Offsite Movement of Agricultural Residues: Alfalfa* , UC ANR Publication 8459.

Soil Erosion and Particulates

Soil sediments are considered a pollutant in surface waters. While alfalfa is not a major contributor of sediments to surface waters, erosion can occur at the tail ends of fields moving

sediments into natural waterways. Careful water management as well as techniques such as vegetated drainage ditches can help minimize soil erosion.

Estimating Evapotranspiration to Apply an Accurate Amount of Water

Too much water results in a lack of oxygen to the root system, diseases, and plant death resulting in stand loss and weed intrusion. Monitoring evapotranspiration (ET), and irrigating according to crop needs maintains good plant health and saves water. Watching evapotranspiration is particularly helpful with sprinkler and subsurface drip irrigation where it is easier to monitor and adjust application rates.

Soil Moisture Monitoring

Soil moisture monitoring is an effective method to indicate whether too little or too much water has been applied, and should be used along with evapotranspiration estimates to schedule irrigations accurately and in a timely fashion.

Redesigning Surface Systems

The use of shorter check flood systems, drip irrigation, laser leveling to remove low spots in the field, and automation of surface water delivery systems will help reduce alfalfa damage from standing water.

Effective Use of Sprinkler Systems and Effects on Foliar Diseases

These can greatly reduce off-site water movement compared with flood irrigation. Sprinklers are particularly useful for stand establishment. However, sprinkler irrigation may encourage foliar diseases such as downy mildew, leafspot, spring blackstem, and sclerotinia. With heavy plant canopies, less frequent irrigations to allow the crop to dry between irrigations may be beneficial.

Subsurface Drip Irrigation System Effects on Weeds and Rodents

Drip irrigation in alfalfa can result in greatly reduced weed pressure due to dry soil surfaces. However, gophers and other rodents can be extremely damaging in drip-irrigated fields than in surface-irrigated fields due to feeding on the subsurface drip lines, impacting water delivery. If possible, have a check system in place in subsurface drip fields to allow for flood irrigation to help reduce gopher and ground squirrel populations if needed.

Flood Irrigation Impacts on Rodents

Though tail-water in surface-irrigated fields is difficult to manage, flood irrigation nearly eliminates ground squirrels and can significantly decrease gopher numbers.

Insects and Mites

(Section reviewed 1/17)

General Insect Management and Monitoring

SAMPLING WITH A SWEEP NET (1/17)

Sampling with a sweep net is commonly used to monitor many alfalfa pests when alfalfa plants are at least 6- to 10- inches tall. (For shorter regrowth, do not rely on sweep net sampling to determine pest numbers; instead estimate plant damage visually). Sweep net sampling is also used for estimating numbers of lady beetles. A 15-inch diameter sweep net is the standard sampling tool used in alfalfa. The way in which this sweep net is used can greatly influence its effectiveness for collecting insects in alfalfa and, consequently, pesticide application decisions based on the number of insects caught. Therefore, standard methods have been developed for sampling so results are standardized.

To use a sweep net, swing it in a 180º arc such that the net rim strikes the top 6 to 8 inches of alfalfa growth. Hold the net slightly less than vertical so the bottom edge strikes the alfalfa before the top edge. This will facilitate getting the insects into the net. Each 180º arc counts as one sweep. A common practice is to take a sweep from right to left, walk a step, and take another sweep, left to right.

After taking the desired five sweeps, quickly pull the net through the air to force all insects into the bottom of the net bag and grasp the net bag with a hand at about the mid-point to trap the insects in the bottom of the sweep net. Slowly invert the net bag, while releasing your grasp on the bag allowing the insects to escape and count the numbers of key species. Many slow-moving insects, such as weevil larvae, aphids, and caterpillars can be counted by turning the net onto a white pan or even the hood of a vehicle. Divide totals by five to get the average number of insects per sweep. To get a good representation of insect numbers in the alfalfa field, take sweep net samples in four different areas of the field starting from the field margin and working towards the interior of the field.

If the numbers are so large that counting in the field is difficult, the bag contents can be placed into a plastic or paper bag and the counting done after cooling the sample to slow down the insect movement. Pest management decisions, however, are generally made before such high numbers occur. Collect samples from at least four areas of the field but avoid unusual parts of the field, such as field edges. The exception to this is when sampling leafhoppers, which tend to be concentrated initially on the field margins. The table below details specific sweeping guidelines for each pest.

GUIDELINES FOR SWEEP NET SAMPLING

	Egyptian alfalfa weevil and alfalfa weevil	Alfalfa caterpillars and armyworms	Leafhoppers
When to start	In late January or later, depending on location. Sweep fields after weevil larvae appear (as evidenced by chewed leaves). (If plants are too short to sweep, monitor terminals for damage.)	In early summer (June) when plants reach adequate height.	In May to September at the first sign of injury (wedge-shaped leaf burn at the tip of leaves).
How often	Twice a week	Twice a week	Weekly until numbers approach the threshold. Sample field edges if an adjacent crop infested with leafhoppers is being harvested.
Divide field	4 sections; 5 sweeps per section (20 sweeps total)	4 sections; 5 sweeps per section (20 sweeps total)	4 sections; 5 sweeps per section
Special instructions	Continue to monitor weekly during spring or after a pesticide application: • *Central Valley* through June • *Southern deserts* until March • *Intermountain areas* until mid-June. Keep records on monitoring form (*available online)*.	Identify type of caterpillar. Count armyworms 0.5 inch or longer. Record the number of healthy and parasitized (pull apart caterpillars and look for parasite larvae) Keep records on monitoring form (*available online)*.	Count number of adults and nymphs. Be sure to include field edges when sampling. Keep records on monitoring form*(available online)*.
Treatment thresholds	For sweep net sampling, spray when weevil larval count reaches an average of 20 larvae per sweep.	If cutting is not scheduled soon after monitoring, spray when there is an average of: • 10 or more nonparasitized alfalfa caterpillars per sweep • 15 or more nonparasitized armyworms per sweep or • 10 or more per sweep of both species that are nonparasitized	If alfalfa is 2 or more weeks from harvest, apply pesticides if counts reach 5 leafhoppers per sweep (adults and nymphs). For fields scheduled to be harvested in 10 days to 2 weeks, spray if counts reach 10 leafhoppers per sweep.

APHID MONITORING (1/17)

Using the procedures below, take weekly stem samples for blue alfalfa aphids, pea aphids, cowpea aphids, and natural enemies during stand establishment and in spring- and fall-established stands. Sample for cowpea aphids, spotted alfalfa aphids, and natural enemies in summer-established stands.

Natural enemies can quickly reduce aphid infestations. As aphid threshold populations are approached, check every 2 to 3 days to determine if natural enemies and disease are reducing numbers. For more detailed treatment threshold information, see the monitoring form *(available in the online version of this guideline).*

HOW TO SAMPLE

(View photos online of aphids)

- Randomly choose 5 stems from each of 4 areas per field, noting if the average plant height is less than 10 inches, 10 to 20 inches, or more than 20 inches.
- Bend each stem sample over a white pan and tap; dislodged aphids will fall in. The stem can also be shaken into a sweep net if a pan is not available.
- Take sweep net samples, see SAMPLING WITH A SWEEP NET), for lady beetle adults and larvae, fungal-killed aphids, parasitized aphid mummies, and the presence of other predators such as syrphid flies and lacewing larvae. Natural enemies can reduce aphid numbers.
- Record results on a monitoring form. A pesticide application may be warranted if natural enemies fail to keep the aphid numbers in check.

PROCEDURE AND TREATMENT THRESHOLD

Treatment threshold	Stand establishment and Established stands (winter, spring, and fall)	Established stands (summer)
Aphid species	Blue alfalfa, Pea aphids, Cowpea aphid, and natural enemies	Cowpea aphid, spotted alfalfa aphid, and natural enemies
When to start	Late fall	Early summer (June for spotted alfalfa aphid)
How often	Weekly	Weekly
Special instructions	If both blue alfalfa and pea aphid species are present, use the blue alfalfa aphid treatment thresholds. No thresholds are established for aphids on seedling alfalfa; watch for plant damage.	If only spotted alfalfa aphids are present and reach treatment thresholds, be sure to sweep and compare spotted alfalfa aphids and lady beetles according to the following "Treatment Thresholds" table.
If natural enemies are present	Check the field every 2 to 3 days to see if the aphid numbers decrease. If they do, insecticides may not be necessary.	

TREATMENT THRESHOLDS (#APHIDS/STEM)

Pest	Plants less than 10"	Plants 10-20"	Plants more than 20"	Summer	Spring	After last fall cutting
Pea aphid	40-50	70-80	100+	—	—	—
Blue alfalfa aphid	10-12	40-50	40-50	—	—	—
Cowpea aphid	10-12	40-50	40-50	—	—	—
Spotted alfalfa aphid	—	—	—	40*	20*	50-70

*Do not apply a pesticide if there are 4 or more adult lady beetles or 3 or more lady beetle larvae per sweep for every 40 aphids counted per stem (on stubble this ratio is 1 larva per sweep to every 50 aphids per stem).

ALFALFA CATERPILLAR AND ARMYWORM MONITORING (1/17)

Start sweeping for beet armyworm, western yellowstriped armyworm, and alfalfa caterpillars in the early summer (late May or June, as soon as you see caterpillars in the field) and continue through early fall. Large numbers of yellow and white butterflies during late spring or summer is a warning sign that alfalfa caterpillar numbers may be increasing. See SAMPLING WITH A SWEEP NET for more details on sweeping.

Use a monitoring form with treatment thresholds to record observation*s (available in the online version of this guideline).*

HOW TO MONITOR

(*View photos to identify caterpillars in the online version of this guideline*)

- Take a weekly sweep net sample in fields that have adequate plant height to monitor for beet armyworm, western yellowstriped armyworm, and alfalfa caterpillars.
- Divide each field into 4 sections and take 5 sweeps per area with a 15-inch diameter sweep net, for a total of 20 sweeps.
- Identify, count, and record the number of healthy and parasitized caterpillars caught in your sweep net and divide that total by the number of sweeps taken.
- Record the average number per sweep on a monitoring form.

To determine if caterpillars are parasitized, pull young worms (at least 0.5 inch long) apart to see if white or green parasitic wasp larvae are inside. Base your population estimates on the average of all sweeps taken in that field, counting only those armyworms collected in sweeps that are at least 0.5 inches in length.

TREATMENT ACTION THRESHOLD

If cutting is not practical or not scheduled soon after monitoring, apply an insecticide if there is an average of:

- 10 or more nonparasitized **alfalfa caterpillars** per sweep.
- 15 or more nonparasitized **armyworms** per sweep.
- 10 or more combined nonparasitized **alfalfa caterpillars** and **armyworms** per sweep.

BIOLOGICAL CONTROL (4/24)

Alfalfa is an important reservoir for natural enemies of insect pests. These natural enemy populations often develop in alfalfa fields and expand into other plantings such as cotton, melons, and beans.

PARASITIC WASPS

Several species of parasitoid (parasite) wasps are found in alfalfa

- *Hyposoter exigua* prey on beet armyworm and western yellowstriped armyworm.
- *Cotesia (Apanteles) medicaginis* prey on alfalfa caterpillars.
- *Trichogramma* spp. prey on various caterpillar pests.
- Parasitoid wasps that attack aphids in alfalfa include: *Aphidius* spp., *Diaeretiella* spp., and *Lysiphlebus* spp.
- *Bathyplectes curculionis* and *Oomyzus incertus* are important parasitoids of the alfalfa weevil.

PREDATORS

Several species of **predaceous bugs** are found in alfalfa. These predators feed on a variety of pests such as alfalfa weevil larvae, aphids, alfalfa caterpillars, beet armyworm, western yellowstriped armyworm, webworms, leafhoppers, and three-cornered alfalfa hopper.

- assassin bugs
- bigeyed bugs
- damsel bugs
- minute pirate bugs
- lady beetles
- collops beetles
- lacewings
- syrphid flies
- spiders

Birds are important predators of insect and rodent pests in alfalfa. Egrets, ibis, and gulls feed on crickets, cutworms, and other insects that are forced to move at the leading edge of flood irrigation water. Blackbirds eat alfalfa weevil larvae, aphids, cutworms, and other insect pests.

Treatment Considerations

Do not apply pesticides to alfalfa until the economic treatment level for a specific pest is reached and the predators and parasites have been assessed for their potential role in controlling the pest. Pesticides often harm natural enemies, leading to severe secondary pest outbreaks. See Relative Toxicities of Insecticides and Miticides Used in Alfalfa to find out which pesticides are most compatible with natural enemies.

NATURAL ENEMIES AND THEIR COMMON PREY IN ALFALFA

Scientific Name	Common Name	Prey
PARASITOID (PARASITE) WASPS		
Anaphes sp.	—	Lygus bug eggs
Aphidius spp.	—	Aphids
Bathyplectes curculionis, B. anurus	—	Alfalfa weevil and Egyptian alfalfa weevil larvae
Cotesia (=Apanteles) medicaginis	—	Alfalfa caterpillar
Hyposoter exiguae	—	Beet armyworm and western yellowstriped armyworm
Oomyzus incertus	—	Alfalfa weevil and Egyptian alfalfa weevil larvae
Trichogramma spp.	—	Caterpillar eggs
PREDATORS		
Chrysoperla sp., *Chrysopa* sp. and others	Lacewings	Aphids and small caterpillars
Coccinella septempunctata, Coccinella spp.	Sevenspotted lady beetle	Aphids and whitefly
Collops spp.	Collops beetles	Various small insects
Geocoris spp.	Bigeyed bugs	Aphids and small caterpillars
Hippodamia convergens	Convergent lady beetle	Aphids and whitefly
Nabis spp.	Damsel bugs	Caterpillars and other insects
Orius spp.	Minute pirate bugs	Aphids and small caterpillars
Scolothrips sexmaculatus	Sixspotted thrips	Various small insects, eggs, and mites
Various species	Spiders	Caterpillars and other insects
Zelus spp., *Sinea* spp.	Assassin bugs	Caterpillars and other insects

RELATIVE TOXICITIES OF INSECTICIDES AND MITICIDES USED IN ALFALFA TO NATURAL ENEMIES AND HONEY BEES (4/24)

Common name (Example trade name)	Mode of Action[1]	Selectivity[2] (affected groups)	Predatory Mites[3]	General Predators[4]	Parasites[4]	Honey bees[5]	Duration of impact to natural enemies[6]
Bacillus thuringiensis ssp. *Aizawai* (XenTari)	11A	narrow (caterpillars)	L	L	L	II	short
Bacillus thuringiensis ssp. *Kurstaki* (Javelin)	11A	narrow (caterpillars)	L	L	L	III	short
beta-cyfluthrin (Baythroid)	3A	broad (insects, mites)	H	H	H	I	moderate
chlorantraniliprole (Vantacor)	28	narrow (primarily caterpillars)	L	L	L/M	III	short
Dimethoate (Dimethoate 400 EC)	1B	broad (insects, mites)	H	H	H	I	long
flonicamid (Beleaf)	29	narrow (aphids, lygus bugs)	L	L	L	III	short
flupyradifurone (Sivanto)	4D	narrow (aphids, leafhoppers)	—	—	—	I	—
hexythiazox (Onager)	10A	narrow (mites)	M	L	L	II	short to moderate
indoxacarb (Steward)	22A	narrow (caterpillars, lygus bugs)	—	L	L	I	moderate
lambda-cyhalothrin (Warrior II)	3A	broad (plant bugs, beetles, caterpillars)	H	H	H	I	moderate
Malathion (Malathion 8-E)	1B	broad (insects, mites)	H	H	H	I	moderate
methomyl (Lannate LV)	1A	broad (insects, mites)	H	H	H	I	moderate
methoxyfenozide (Intrepid)	18	narrow (caterpillars)	L	L	L	II	short
neem oil (Trilogy)	—	broad (soft-bodied insects)	L	L	L	II	short
permethrin (Pounce)	3A	broad (insects, mites)	L	H	H	I	long
spinosad (Entrust)	5	narrow (weevils)	M	M[7]	L/M	II	short to moderate
zeta-cypermethrin (Mustang)	3A	broad (insects, mites)	H	M	M	I	moderate

H = high M = moderate L = low — = no information

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 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). For additional information, see their website at http://irac-online.org/.

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

3 Generally, toxicities are to western predatory mite, *Galendromus occidentalis*. Where differences have been measured in toxicity of the pesticide-resistant strain versus the native strain, these are listed as pesticide-resistant strain or native strain.

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

5 Ratings are as follows: I–Do not apply or allow to drift to plants that are flowering; II–Do not apply or allow to drift to plants that are flowering, except when the application is made between sunset and midnight if allowed by the pesticide label and regulations; III–No bee precaution, except when required by the pesticide label or regulations. For more information about pesticide synergistic effects, see Bee Precaution Pesticide Ratings *(available online at http://ipm.ucanr.edu/beeprecaution/)*.

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

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

Major Insect and Mite Pests

ALFALFA CATERPILLAR (4/24)

Scientific Name: *Colias eurytheme*

DESCRIPTION OF THE PEST

The yellow and white alfalfa caterpillar butterflies lay eggs on new alfalfa growth. Eggs hatch into green caterpillars in 3 to 7 days. Full-grown caterpillars are about 1.5 inches long and are distinguished from other caterpillars on alfalfa by their velvety green bodies with white lines along their sides.

Alfalfa caterpillars overwinter as larvae almost entirely in annual vetch at low altitudes and colonize alfalfa only as the vetch senesces in May and June. Aside from alfalfa and annual vetches, the butterfly also breeds on a variety of clovers and sweet clovers and occasionally on lupines. Caterpillar outbreaks usually result from a flight of butterflies into the field when the alfalfa is less than 6 inches tall.

Alfalfa caterpillar swarms appear to be triggered when growers cut and bale alfalfa when adult numbers are high, with outflow in all directions. Extremely large numbers of adults migrating between fields are often present from June to September in the Central Valley and from May to October in the southern desert. Factors contributing to economically significant caterpillar numbers are

- Slow and uneven crop growth
- Lack of natural enemies
- Hyperparasites (other parasitoid wasps attacking the natural enemy wasps reducing their numbers)
- Hot, dry weather.

There are four to seven generations per year of alfalfa caterpillar, and each generation is closely synchronized with the hay-cutting cycle so that the caterpillar pupates before cutting occurs.

DAMAGE

Alfalfa caterpillars can consume entire leaves. The larger larvae are most destructive. In contrast to armyworms, alfalfa caterpillars do not skeletonize leaves and will also consume the midrib.

MANAGEMENT

The most important way to control the alfalfa caterpillar is to preserve natural enemies that parasitize and prey upon this pest. Use selective insecticides against caterpillar pests in the summer to maintain natural enemies and minimize subsequent build-up of caterpillars. Preserve and encourage natural enemies by avoiding unnecessary insecticide applications for aphids or weevils in the spring.

Biological Control

An important parasite of the alfalfa caterpillar is *Cotesia medicaginis*, a dark brown to black wasp about 0.25 inch long. This wasp stings very small alfalfa caterpillars and lays an egg inside. The egg hatches and the wasp larva eats the inside of the caterpillar. A parasitized caterpillar dies before it reaches 0.5 inch in length. A parasitized caterpillar is

- lighter in color than normal,
- somewhat shiny rather than velvety on the surface, and
- swollen toward the rear.

Grasping the caterpillar at each end of the swelling and pulling it apart will expose the shiny, white parasite. It is important to determine the amount of parasitism because the economic threshold takes parasitism into account. For more information on identifying parasitized caterpillars, see the video in the Alfalfa Caterpillar and Armyworm Monitoring section *(available online)*.

Cultural Control

Border-strip harvesting is a useful method for preserving the natural enemies of both the alfalfa caterpillar and aphids because it helps retain parasite larvae in the field. (For more details, see Border-Strip Harvesting.) Early harvesting of fields infested with economically significant levels of alfalfa caterpillars kills a large number of caterpillars, preserves crop yields, and avoids reducing natural enemy numbers. Time this cutting to avoid serious damage, yet obtain satisfactory yield.

Organically Acceptable Methods

Biological and cultural controls, as well as sprays of *Bacillus thuringiensis,* are acceptable for use on an organically certified crop.

Monitoring and Treatment Decisions

(View photos of caterpillars online)

In early summer start sweeping fields with adequate plant height 2 to 3 times per week to monitor for caterpillars.

Combine monitoring of alfalfa caterpillars with armyworm monitoring as described in Alfalfa Caterpillar and Armyworm Monitoring. Count and record the number of healthy and parasitized caterpillars caught in your sweep net on a monitoring form *(available online)*.

If cutting is not practical or not scheduled soon after monitoring, apply an insecticide if there is an average of:

- 10 or more nonparasitized alfalfa caterpillars per sweep,
- 15 or more nonparasitized armyworms per sweep, or
- 10 or more nonparasitized alfalfa caterpillars and armyworms combined per sweep.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.			
A. BACILLUS THURINGIENSIS ssp. KURSTAKI (Javelin WG)#	0.25–1.5	4	0
MODE-OF-ACTION GROUP NUMBER[1]: 11A COMMENTS: *Bacillus thuringiensis* will give satisfactory control of the alfalfa caterpillar, does not affect natural enemies, and leaves no undesirable residue on the hay. Upon ingesting *Bacillus* the caterpillars cease feeding but may remain on plants 3 to 4 days before dying.			
B. CHLORANTRANILIPROLE (Vantacor)	1.2–2.5 fl oz	4	0
MODE-OF-ACTION GROUP NUMBER[1]: 28 COMMENTS: To reduce the development of resistance, do not make more than two applications of any group 28 insecticides in a crop year.			
C. INDOXACARB (Steward EC)	6.7–11.3 fl oz	12	7

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
MODE-OF-ACTION GROUP NUMBER[1]: 22A COMMENTS: Make no more than one application per cutting. Steward EC can be used for alfalfa grown for seed, but seeds cannot be used for sprouts intended for human consumption or livestock feed. All seed must be tagged, "Not for human or animal use."			
D. METHOXYFENOZIDE (Intrepid 2F)	Label rates	4	see label
MODE-OF-ACTION GROUP NUMBER[1]: 18 COMMENTS: Make no more than one application per cutting. Not for use in alfalfa grown for seed or for sprouts for human consumption.			

** 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 personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on certified organic crops.

1 Group numbers for insecticides and miticides are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides 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. For more information, see irac-online.org.

BEET ARMYWORM (1/17)

Scientific Name: *Spodoptera exigua*

DESCRIPTION OF THE PEST

The adult beet armyworm is a small, mottled gray- or dusky-winged moth. The moths are nocturnal (fly mostly at night) but may be seen by taking sweep net samples in the field.

Females deposit pale greenish or pinkish, striated eggs on the upper side of the alfalfa leaves in small or large masses covered with white cottony material. The eggs hatch in a few days, and the tiny caterpillars begin feeding on the plant. Heavy feeding on the tips of plant stems can cause flagging as terminal leaves turn white. The smooth-skinned caterpillars become full grown in about 2 to 3 weeks and are about 1.25 inches long. They range from olive green to almost black in color down the middle of the back with a yellow stripe on each side of the body.

Armyworms are common pests in the Central Valley and desert valleys from June through September. There are at least 5 generations per year in the low desert and four in the Central Valley. The final generation may overwinter as large larvae or pupae.

DAMAGE

Armyworms skeletonize foliage, leaving veins largely intact. First- and second- instar larvae tend to feed in clusters around the egg mass from which they hatch. This frequently causes a tattered appearance to the terminals. This whitish appearance caused by the feeding is known as "whitecaps" and can be seen across a field. As the larvae mature and move to more stems, the areas of "whitecaps" tend to coalesce and the entire field takes on a tattered look.

MANAGEMENT

Populations of armyworms are frequently controlled by natural enemies and are more or less cyclic, occurring in large numbers only every few years. Early harvest, border cutting, and biological control are important components of a management program that will prevent damage from armyworms.

Biological Control

Natural enemies can provide good control of armyworms in many fields.

Predators include bigeyed bugs, spiders, minute pirate bugs, damsel bugs, assassin bugs, and lacewings.

The parasitic wasp, *Hyposoter exiguae,* is the most important of at least 10 parasites attacking this pest. Sample for parasitism by pulling the heads from older caterpillars and squeezing the body contents out toward the head end. *Hyposoter* larvae are a light, translucent green color.

Viral diseases of armyworms are also important natural control agents under certain conditions of temperature and humidity. Diseased caterpillars first appear yellowish and limp. After death they hang from plants as shapeless forms oozing the disintegrated body contents.

Cultural Control

Border-strip harvesting is a useful method for preserving natural enemies because it helps retain parasite larvae in the field. For more details, see BORDER-STRIP HARVESTING. Early cutting will give satisfactory control if the infestation appears late in the cutting cycle.

Organically Acceptable Methods

Biological and cultural controls, as well as sprays of *Bacillus thuringiensis*, are acceptable for use on an organically certified crop.

Monitoring and Treatment Decisions

In early summer start sweeping fields with adequate plant height 2 to 3 times per week to monitor for caterpillars and continue through fall. Divide each field into 4 sections and take 5 sweeps per section with a 15-inch diameter sweep net, for a total of 20 sweeps. For information on sampling, see SAMPLING WITH A SWEEP NET.

Combine monitoring of armyworms with monitoring for alfalfa caterpillar as described in ALFALFA CATERPILLAR AND ARMYWORM MONITORING. Count and record the number of healthy and parasitized caterpillars caught in your sweep net on a monitoring form *(available online)*.

If cutting is not practical or not scheduled soon after monitoring, apply a pesticide if there is an average of:

- 10 or more nonparasitized alfalfa caterpillars per sweep,
- 15 or more nonparasitized armyworms per sweep, or
- 10 or more nonparasitized alfalfa caterpillars and armyworms combined per sweep.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
TABLE UPDATED 4/24			
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. METHOXYFENOZIDE (Intrepid 2F)	Label rates	4	see label
MODE-OF-ACTION GROUP NUMBER[1]: 18 COMMENTS: Make no more than one application per cutting. Not for use in alfalfa grown for seed or for sprouts for human consumption.			
B. CHLORANTRANILIPROLE (Vantacor)	1.2–2.5 fl oz	4	0
MODE-OF-ACTION GROUP NUMBER[1]: 28 COMMENTS: Make no more than one application per cutting. To reduce the development of resistance, do not make more than two applications of any group 28 insecticides in a crop year.			
C. INDOXACARB (Steward EC)	6.7–11.3 fl oz	12	7
MODE-OF-ACTION GROUP NUMBER[1]: 22A COMMENTS: Make no more than one application per cutting. Steward EC can be used for alfalfa grown for seed, but seeds cannot be used for sprouts intended for human consumption or livestock feed. All seed must be tagged: "Not for human or animal use.".			
D. BACILLUS THURINGIENSIS ssp. AIZAWAI (XenTari)#	0.5–2 lb	4	0
MODE-OF-ACTION GROUP NUMBER[1]: 11A COMMENTS: Apply when larvae are small (in first or second instar). Does not harm beneficial insects. Repeat pesticide application as necessary.			

** See label for dilution rates.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)

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

Acceptable for use on certified organic crops.

1 Group numbers for insecticides and miticides are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides 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. For more information, see irac-online.org.

BLISTER BEETLES (1/17)

Scientific Name: *Epicauta* spp., *Lytta* spp., *Tegrodera* spp.

DESCRIPTION OF THE PESTS

Blister beetles are narrow and elongate and the covering over the wings is soft and flexible. They may be solid colored (black or gray) or striped (usually orange or yellow and black) and are among the largest beetles likely to be found in a sweep net sample in alfalfa.

Blister beetles have an unusual and complex life cycle. Females deposit clusters of eggs in depressions in the soil and the newly hatched larvae (called triungulin) seek out subterranean grasshopper egg pods or eggs of ground-nesting bees to complete development. The triungulin of some species of blister beetles "hitch a ride" back to the hive with adult bees to feed on bee eggs. The larvae pass through three more growth stages, with each becoming more sedentary, and eventually change to pseudopupae, which is the overwintering stage. In the spring, they enter the pupal stage from which adults emerge. Adults survive summer and deposit eggs to complete the cycle.

DAMAGE

Blister beetles do not cause widespread feeding damage to alfalfa; however, they contain a chemical, cantharidin, which is toxic to livestock. Cantharidin is contained in the hemolymph (blood) of the beetles, and can contaminate forage directly, when beetles killed during harvest are incorporated into baled hay, or indirectly, by transfer of the hemolymph from crushed beetles onto forage. Horses are particularly susceptible to the toxic effects of cantharidin. Consuming as few as six beetles can kill a horse.

As the name implies, handling these insects may result in blisters, similar to a burn, on the hands or fingers. Blister beetles have been a problem in alfalfa in the northern United States, the Midwest, and the south for many years, but are an occasional problem in California.

MANAGEMENT

There are no known predators or parasites that effectively control blister beetles. Blister beetles are attracted to blooming alfalfa. Therefore, to reduce the incidence of blister beetles in alfalfa, cut hay before peak bloom. Alfalfa fields near natural areas or rangelands may have higher levels of blister beetles due to the availability of grasshopper egg pods or ground-nesting bees in these undisturbed areas. Blister beetles may not be present all summer (each species has a peak period of activity), thus samples and observations may be helpful to determine activity patterns in particular areas. Research has not been conducted to determine this.

These beetles are also found on the edge of the field or congregated in groups within the field. Skip such areas when cutting or pick up the bales for these areas separately and isolate them from the rest of the field. No treatment thresholds have been established for blister beetles and insecticide applications generally are not needed.

BLUE ALFALFA APHID (1/17)

Scientific Names: Blue alfalfa aphid: *Acyrthosiphon kondoi*

DESCRIPTION OF THE PESTS

(View photos online to identify aphids)
The blue alfalfa aphid is a large blue-green aphid with long legs, antennae, cornicles, and cauda. It is similar in appearance to the pea aphid but can be distinguished by examining the antennae. The antennae of the pea aphid have narrow dark bands on each segment, whereas those of the blue alfalfa aphid gradually darken to brown as you near the tip of the antennae.

Both the blue alfalfa aphid and the pea aphid prefer cooler temperatures (optimal temperature for development of both blue alfalfa and pea aphid is around 60°F); however, the blue alfalfa aphid is more tolerant than the pea aphid of cool temperatures and appears earlier in growing season. The biology and population levels of the blue alfalfa aphid has changed in recent years. Damaging numbers are most common in the mid- to late winter in the desert production areas, in the late winter to early spring in the Central Valley, and the spring to early summer in the intermountain areas. However, blue alfalfa aphids may also be found in the fall in many areas.

The blue alfalfa aphid and the pea aphid may occur in mixed populations. Historically, both species were present in alfalfa fields at the same time as the alfalfa weevils. However, now both blue alfalfa and pea aphids can be present in the fall, winter, and spring. The blue alfalfa aphid colonizes the plant terminals while pea aphid is usually more generally distributed. Both species prefer to feed on the stems rather than the leaves.

DAMAGE

While feeding on alfalfa, the blue alfalfa injects a toxin that retards growth, reduces yield, and may even kill plants. The toxin injected by the blue alfalfa aphid is more potent than that of the pea aphid (pea aphid toxin itself is not particularly damaging to alfalfa plants). Toxin that remains in the stems and crown after harvest of the upper plant material may continue to retard stem growth and elongation and may carry over to the next cutting, or even the subsequent two cuttings.

Damage can also reduce the alfalfa's feeding value. A black fungus, sooty mold, grows on the honeydew excreted by the aphid and reduces palatability to livestock. Damage is more severe on short growth alfalfa than on taller alfalfa for both species.

MANAGEMENT

Using resistant varieties of alfalfa and encouraging populations of natural enemies are very important in managing blue alfalfa aphid. It is critical to distinguish between the blue alfalfa and pea aphids because blue alfalfa aphid causes more damage than pea aphid, and the two species have different treatment thresholds. Natural enemies, especially lady beetles, are monitored along with the aphids to determine the need for a pesticide application. Aphids may become a more severe problem when weevil sprays reduce the numbers of natural enemies. Border harvesting or strip cutting can be a useful tool for preserving natural enemies.

Resistant Varieties

Planting alfalfa varieties resistant to blue alfalfa aphid has been the most effective means of controlling aphids in alfalfa. Prolonged periods of below-normal temperatures, however, may lower plant resistance to blue alfalfa aphid when it is most needed and some crop injury may occur. At around 70°F, the host plant resistance should be fully expressed.

When selecting varieties, consult your cooperative extension advisor for information on resistant varieties suited to your area, or check a list of alfalfa varieties provided by the National Alfalfa & Forage Alliance. Available online at: http://alfalfa.org. Additionally, a yearly alfalfa variety performance report can be found at http://alfalfa.ucdavis.edu.

Biological Control

(View photos online of natural enemies)

The most significant aphid predators are several species of lady beetles, including *Hippodamia convergens* and *Coccinella septempunctata* that attack and consume both the blue alfalfa and pea aphid species. Green lacewings can also be important in regulating aphids and many other predators including bigeyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.), and syrphid fly larvae also play a role.

Aphidius smithi and *A. ervi* are parasites of alfalfa aphids. Large golden-brown aphid mummies on the upper surfaces of leaves indicate parasitization. When a high level of parasitization is present, carefully consider the need to apply insecticides for aphids. Parasites frequently provide adequate control.

A naturally occurring fungal disease, which is most prevalent during cool, rainy, or foggy weather, may also control aphids.

Cultural Control

Use border-strip cutting during harvest to help maintain populations of parasites and predators within the field. For more details, see BORDER-STRIP HARVESTING.

Organically Acceptable Methods

The use of resistant varieties, biological control, and cultural control are acceptable to use on an organically certified crop. Organically certified insecticides such as azadirachtin (Neemix), neem oil (Trilogy), and pyrethrin (PyGanic) are registered for use on alfalfa to control aphids. Studies conducted in California, however, have shown that at best they provide slight suppression of aphids but do not control them.

Monitoring and Treatment Decisions

Start to monitor fields as soon as the first aphids are observed. Use monitoring as described in APHID MONITORING.

If natural enemies fail to keep the aphids in check, an insecticide application may be necessary. Economic treatment thresholds for both blue alfalfa and pea aphids are as follows (if both species are present, use the blue alfalfa aphid treatment levels):

Plant height	Pea aphids	Blue alfalfa aphids
Under 10 inches	40 to 50 per stem	10 to 12 per stem
10 to 20 inches	70 to 80 per stem	40 to 50 per stem
Over 20 inches	100 + per stem	40 to 50 per stem

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least 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. FLUPYRADIFURONE

(Sivanto 200SL)	7–10.5 fl oz	12	7
(Sivanto Prime)	7–14 fl oz	12	7

MODE-OF-ACTION GROUP NUMBER[1]: 4D
COMMENTS: Do not apply more than 28.0 fl oz of Sivanto Prime or 200SL (0.365 lb flupyradifurone)/acre per calendar year on alfalfa, regardless of product or formulation.

B. FLONICAMID

(Beleaf 50SG)	2.8 oz	12	62

MODE-OF-ACTION GROUP NUMBER[1]: 29
COMMENTS: Use allowed under a 24c registration (SLN CA-140006).

C. DIMETHOATE

(Dimethoate 2.67EC)	Label rates	48	See comments

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: Preharvest interval (PHI) is 10 days for harvest or pasturing; for alfalfa seed: do not feed or graze livestock on treated crops, hay threshings, or stubble within 20 days of application. Check label to see if product allows only one application per year or per cutting. Do not apply when bees are present.

D. METHOMYL*

(Lannate SP)	0.5–1 lb	48	7

MODE-OF-ACTION GROUP NUMBER[1]: 1A
COMMENTS: Highly toxic to bees: do not spray directly or allow drift onto blooming crops or weeds where bees are foraging. Can also kill natural enemies.

E. LAMBDA-CYHALOTHRIN*

(Warrior II with Zeon)	1.28–1.92 fl oz	24	See comments

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Preharvest interval (PHI) is 1 day for forage and 7 days for hay. Can be disruptive to natural enemies. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

F. ZETA-CYPERMETHRIN*

(Mustang)	2.4–4.3 fl oz	12	See comments

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Preharvest interval (PHI) is 3 days for cutting or grazing and 7 days for harvesting seed. Can be disruptive to natural enemies. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

** 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 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). For additional information, see their website at http://irac-online.org/.

CLOVER ROOT CURCULIO (4/24)

Scientific Name: *Sitona hispidulus*

DESCRIPTION OF THE PEST

Adults of the clover root curculio are slightly smaller than alfalfa weevil adults and are a mottled gray-brown with no distinct patterns. The grublike larvae are white and feed on alfalfa roots during the spring. The larvae can be difficult to find because they are in the soil and often may be inside the root nodules during early instars. The life cycle is similar to alfalfa weevil in that the adults leave the alfalfa fields and spend the summer in protected areas. There is one generation per year.

The clover root curculio is a recognized alfalfa pest in most U.S. growing areas, but information on this pest in California is limited. Clover root curculio is most likely to be found in June and is apparently more common in sandy soils than in the heavier soils.

DAMAGE

The damage is usually observed as patches of poor growth or stand decline because the larvae gouge, even girdle, the taproots. The gouges can be a point of entry for root rot diseases. This damage has been shown to be detrimental to alfalfa yield and stand longevity in the eastern United States. Damage has also been reported in California, but the severity and distribution of damage in the state has not been assessed.

MANAGEMENT

There are no thresholds or control measures for this pest. Crop rotation to non-legume crops is the best way to manage this pest. There are no insecticides registered for clover root curculio larvae.

Cultural Control

Rotate out of alfalfa and other legumes for at least one year. Avoid planting alfalfa next to infested fields (since seedling roots are weaker and more susceptible to feeding damage). Provide good irrigation and fertilization to prevent plant stress that might make stands more susceptible to decline. Clean equipment when moving between fields.

COWPEA APHID (1/17)

Scientific Name: *Aphis craccivora*

DESCRIPTION OF THE PEST

(View photos online to identify aphids)
Cowpea aphid is readily distinguishable from other aphids inhabiting alfalfa because it is the only black aphid found infesting the crop. It is a relatively small aphid and the adult is usually shiny black while the nymph is slate gray. The appendages are usually whitish with blackish tips.

In the Sacramento Valley, cowpea aphid numbers are highest from April to September; numbers peak from October to January in the desert; and in the San Joaquin Valley, cowpea aphid can reach treatable levels from March to October. Cowpea aphids are a sporadic pest in the Intermountain Region.

This aphid has an extensive host range, including beans, cotton, and weeds.

DAMAGE

Cowpea aphid injects a powerful toxin into the plant while feeding and, when their numbers are high, this can stunt or even kill plants. While feeding, this aphid produces a considerable amount of honeydew upon which sooty mold can grow. The black sooty mold reduces photosynthesis and may make leaves unpalatable to livestock. The honeydew also makes the alfalfa sticky, which causes problems with harvest.

MANAGEMENT

There are no known varieties of alfalfa that are resistant to cowpea aphid and economic thresholds have not been developed specifically for this pest. Treatments may be necessary if large numbers of cowpea aphids are present. Border harvesting or strip cutting can be important for preserving natural enemies.

Biological Control

(View photos online of natural enemies)
Two common aphid parasites, *Lysiphlebus* sp. and *Diaeretiella* sp., have been identified from the desert production areas. Although parasitism as high as 95% has been documented, aphid numbers can become so high that enough nonparasitized individuals remain to cause significant injury.

This aphid is also susceptible to the usual complement of aphid predators including lady beetles (convergent lady beetle, multicolored Asian lady beetle, twicestabbed lady beetle), lacewings, bigeyed bugs, damsel bugs, and syrphid flies. Early in the season (February and early-March) many of these predators are generally not active, but in the low desert the sevenspotted lady beetle, *Coccinella septempunctata*, is abundant and feeding on the aphid.

Cultural Control

Use border-strip cutting during harvest to help maintain populations of parasites and predators within the field. For more details, see BORDER-STRIP HARVESTING.

Organically Acceptable Methods

Use biological and cultural controls on organically certified crops. Organically certified insecticides such as azadirachtin (Neemix), neem oil (Trilogy), and pyrethrin (PyGanic) are also registered for use on alfalfa to control aphids. Studies conducted in California, however, have shown that at best they provide some suppression of populations but do not control them.

Monitoring and Treatment Decisions

Cowpea aphid infestations are typically patchy in a field, especially early infestations. Stems on alfalfa plants in infested areas are often completely covered with aphids, whereas plants in other areas of the field may appear aphid-free. Because of the spotty distribution of cowpea aphid infestations, spot treatments may be feasible, especially if the infestation is on the field border.

On dormant alfalfa, pay close attention to plants as they begin breaking dormancy. If shoots fail to grow normally and cowpea aphid is present, consider control measures.

Start to monitor fields in February for cowpea aphid and continue to monitor this aphid through fall; monitoring can be combined with that of blue alfalfa and pea aphid as described in APHID MONITORING. (During summer months, monitoring of cowpea aphid can be combined with that of spotted alfalfa aphids.)

Record counts on a monitoring form. *Monitoring forms are available on the online version of this guideline.*

No guidelines or economic threshold levels have been established for cowpea aphid in alfalfa. Until economic thresholds are developed for the cowpea aphid, use the following thresholds, which were developed for the blue alfalfa aphid:

Plant height	Aphids
Under 10 inches	10 to 12 per stem
Over 10 inches	40 to 50 per stem

Common Name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

TABLE UPDATED 4/24

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.

The following pesticides have not been tested under California conditions but have been found to be effective in other areas.

A.	FLUPYRADIFURONE			
	(Sivanto 200SL)	7–10.5 fl oz	12	7
	(Sivanto Prime)	7–14 fl oz	12	7
	MODE-OF-ACTION GROUP NUMBER[1]: 4D			
	COMMENTS: Do not apply more than 28.0 fl oz of Sivanto Prime or 200SL (0.365 lb flupyradifurone)/acre per calendar year on alfalfa, regardless of product or formulation. Highly toxic to adult alfalfa leafcutting bee via direct contact exposure. Do not apply to foliage when managed alfalfa leafcutting bees are foraging in the treatment area.			
B.	FLONICAMID			
	(Beleaf 50SG)	2.8 oz	12	14
	MODE-OF-ACTION GROUP NUMBER[1]: 29			
	COMMENTS: Use allowed under a 24c registration (SLN CA-140006).			
C.	DIMETHOATE			
	(Dimethoate 2.67EC)	0.75–1.5 pt	48	See comments
	MODE-OF-ACTION GROUP NUMBER[1]: 1B			

Common Name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

TABLE UPDATED 4/24

COMMENTS: Check label to see if product allows only one application per year or per cutting. Preharvest interval (PHI) is 10 days for harvest or pasturing; for alfalfa seed: do not feed or graze livestock on treated crops, hay threshings, or stubble within 20 days of application. Do not apply when bees are present.

D. MALATHION
(Malathion 8-E) 1–1.25 pt 12 0
MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: *Use only when other products cannot be used.* Do not apply when bees are present.

E. LAMBDA-CYHALOTHRIN
(Warrior II with Zeon) 1.28–1.92 fl oz 24 See comments
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Preharvest interval (PHI) is 1 day for forage and 7 days for hay. Can be disruptive to natural enemies. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

F. ZETA-CYPERMETHRIN
(Mustang) 2.4–4.3 fl oz 12 See comments
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Preharvest interval (PHI) is 3 days for cutting or grazing and 7 days for harvesting seed. Can be disruptive to natural enemies. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

G. BETA-CYFLUTHRIN
(Baythroid XL) 2.8 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Can be disruptive to natural enemies. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without personal protective equipment. 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 for insecticides and miticides are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides 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. For more information, see irac-online.org.

CUTWORMS (1/17)

Scientific Names: Granulate cutworm: *Feltia subterranea*
Army cutworm: *Euxoa auxiliaris*
Variegated cutworm: *Peridroma saucia*

DESCRIPTION OF THE PESTS

Cutworms are only occasional pests of high desert, Central Valley, and intermountain alfalfa but are frequent pests in the low desert where alfalfa is sometimes planted on beds. The granulate and the variegated cutworms are the two species that most commonly attack low desert alfalfa.

Female moths lay white or greenish eggs in irregular masses on leaves or stems of plants, often near the base of the plant. Eggs darken as they approach hatching. Full grown caterpillars are about 1.5 to 2 inches and appear as smooth-skinned caterpillars of various colors and patterns. Larvae frequently roll into a C-shape when disturbed. Cutworms feed at night and hide during the day in soil cracks and under debris and loose soil.

DAMAGE

Variegated cutworms may develop in weedy areas and migrate into seedling stands or occasionally mature stands. Injurious numbers usually occur from April to late June. Seedling alfalfa stands can be severely damaged by cutworms cutting the seedlings off at or just below the soil surface. Established fields are damaged when cutworms cut off new growth or feed on the alfalfa foliage. Sometimes they feed underneath the alfalfa windrows, causing severe damage.

Granulate cutworm is a devastating pest of bed-planted alfalfa and can also be a pest of alfalfa planted between borders. Low desert alfalfa fields are most severely attacked from May through October, but the pest occurs year round in fields. Established alfalfa fields can be severely injured when cutworms cut off new shoots at or below ground level following harvest. The pest often goes undetected after cutting and hay removal but the problem becomes apparent when the field is irrigated and there is little or no regrowth.

MANAGEMENT

Tillage, flood irrigation, and weed control are important in cutworm management. When damage is severe in seedling fields, apply an insecticide.

Cultural Control

Tillage helps to limit cutworm numbers prior to planting; seedlings in well-tilled fields—especially when there is an interval between crops—are less likely to have cutworm problems. Keep the field and field edges weed-free. Flood irrigation can drown many cutworm larvae, reducing their numbers. Flood irrigation during the day will attract many birds that prey on the cutworms as the advancing water forces them from hiding.

Organically Acceptable Methods

Only cultural control methods are available for organic production systems.

Monitoring and Treatment Decisions

Cutworm infestations are sporadic, and treatment guidelines have not been established in California. Check for cutworms by looking under duff and carefully digging to a depth of 1 inch in loose soil near alfalfa crowns. Look for small chewing or bite marks in the alfalfa roots, which create entry wounds for

secondary pathogens such as *phytophthora*. When cutworm numbers exceed one or two per foot of row or severe damage is apparent, it may be necessary to apply a pesticide.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least 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. INDOXACARB (Steward EC) MODE-OF-ACTION GROUP NUMBER[1]: 22A COMMENTS: Make no more than one application per cutting. Not for use in alfalfa grown for seed or for sprouts for human consumption. Do not apply more than 45 fl oz/acre per crop season.	6.7–11.3 fl oz	12	7

** 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 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). For additional information, see their website at http://irac-online.org/.

GRASSHOPPERS (1/17)

Scientific Names: *Melanoplus* spp., *Trimerotropis* spp.

DESCRIPTION OF THE PEST

Grasshoppers are readily distinguished from most other insects by their hind legs, which have greatly enlarged femurs that are well adapted for jumping. Their bodies are robust and their antennae relatively short. In contrast, another alfalfa pest in the order Orthoptera, crickets, have long antennae. Most grasshoppers are winged and many are good flyers, although a few species are flightless.

Grasshoppers may be a pest in alfalfa production, but vary greatly in importance from area to area and season to season. They sometimes develop in uncultivated areas and move into cultivated fields. They should be controlled before they enter the alfalfa field.

DAMAGE

Grasshoppers feed on leaves and stems. When numbers are high they can cause severe defoliation.

MANAGEMENT

Economically significant levels vary with the growth of the crop; in general, 15 grasshoppers per square yard or higher are considered severe. Control measures will depend on the growth of the crop and the stage of development of grasshoppers present. Grasshoppers are best controlled before they enter alfalfa fields. Check with your county agricultural commissioner regarding the current registration of baits to control grasshoppers in alfalfa fields.

GROUND MEALYBUG (1/17)

Scientific Name: *Rhizoecus kondonis*

DESCRIPTION OF THE PEST

Ground mealybug is a small, whitish insect found on the roots of alfalfa and other crops. It is restricted to the heavier soils of the Sacramento Valley and is not found in the San Joaquin or Imperial valleys.

The ground mealybug has slender, waxy filaments that form a sort of netting over some individuals. The ground mealybug also secretes a small amount of wax, which can give the soil a somewhat bluish appearance when the mealybugs are abundant. There are three generations per year with numbers peaking in the early winter, spring, and mid-summer periods. The eggs, nymphs and adults all occur in the soil.

DAMAGE

The ground mealybug feeds on alfalfa roots and can cause severe yield losses. Feeding interacts with stressful environmental conditions, resulting in greatly reduced plant growth that is particularly evident during summer. Infestations in alfalfa fields generally occur in "circular" patches and spread slowly, as the mealybugs feed on their hosts and move out from a central infestation point.

MANAGEMENT

The best place to monitor for ground mealybug is right at the line between healthy and unhealthy plants. Look for bright white tiny insects that crawl around the roots, about 6-12 inches in the soil.

There are no thresholds or control measures for this pest. Crop rotation may help, but this pest appears to survive on several crop plant and weed species. Because there is differential survival across host species, rotation to a less preferred host may aid in management. In a greenhouse study, greatest survival was on potato, tomato, safflower, and alfalfa, followed by cotton, cantaloupe, dryland rice, sugarbeets, and wheat. There was only slight survival on field corn and kidney beans. However, there were no plant species without some level of survival.

LEAFHOPPERS (1/17)

Scientific Names: Garden leafhopper: *Empoasca solana*
Potato leafhopper: *E. fabae*
Mexican leafhopper: *E. mexara*

DESCRIPTION OF THE PESTS

Several species of *Empoasca* leafhoppers occur in alfalfa. They all have the same general overall appearance: small [0.125 inch (3.2 mm) long], bright green, wedge-shaped bodies. Nymphs (immatures) also have green wedge-shaped bodies and run rapidly when disturbed. They may run forward, backward, or from side to side. Their curious movement plus their shape serve to distinguish them from lygus bug nymphs and slower moving aphids. Other green leafhoppers may be present in alfalfa, such as the threecornered alfalfa hopper, but they are much larger in size. Other small leafhoppers found in alfalfa are brown or gray in color and do no apparent damage.

DAMAGE

The most common damage symptom is a yellow, wedge-shaped area at the tip of the leaf known as 'hopperburn'. Frequently, the leaf margin and tissue surrounding this area turns red. This symptom may occasionally be confused with boron deficiency but can easily be distinguished from it by the presence of the insects. Empoasca leafhoppers also inject a toxin into the plants, which can cause stunted plants with very short internodes. Stunting and yellowing may persist into the next cutting cycle, even in the absence of leafhoppers.

Although *Empoasca* leafhoppers may be found throughout the year, damage in the Central Valley is generally found during July, August, and occasionally September. In the Imperial Valley, damage may occur from May through September; infestations are often adjacent to or upwind from sugarbeets. Some years this insect is a major pest, other years it is not. Its cyclical nature may be associated with warmer winters where they overwinter in fields or they may be migrating in from other areas.

MANAGEMENT

Scheduling an early cutting can effectively manage damaging leafhopper populations, otherwise insecticide treatment may be warranted.

Cultural Control

If alfalfa is within a few days of harvest, early cutting will control *Empoasca* leafhoppers.

Organically Acceptable Methods

Only cultural controls are acceptable for use on an organically certified crop.

Monitoring and Treatment Decisions

Check the field in July and August (and if necessary into September) to see if leafhoppers are present, especially for fields that are re-growing after harvest. At the first sign of injury, sample the field with a standard sweep net. For stubble fields, watch for damage when walking across the field, including: stunting of plants, poor regrowth, and high leafhopper numbers. Leafhopper infestations usually begin on the field margin so be sure to include field edges in your samples.

- Sample four areas over the entire field by taking five sweeps in each area and counting the number of adults and nymphs.
- Record observations on a monitoring form.

- If alfalfa is 2 or more weeks away from harvest: apply insecticides if counts reach five leafhoppers per sweep (adults and nymphs combined).
- If alfalfa is scheduled for harvest in 10 days to 2 weeks: apply insecticide if counts reach ten per sweep.

For information on sweep sampling, see the SAMPLING WITH A SWEEP NET section.

Leafhopper damage on stubble fields can be much more severe and the toxins they inject can stunt the plants, arresting growth and reducing yields. In these situations, threshold levels may be low. As a result, it is important to visually look at fields for the presence of leafhoppers and damage on newly cut stands. Often, leafhopper infestations with high enough numbers to justify treatment are confined to the first 50 to 100 feet of the field margin. If this is the case, apply insecticide only to the field edges where high leafhopper counts are found.

	Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
TABLE UPDATED 4/24				
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.	FLUPYRADIFURONE			
	(Sivanto 200SL)	7–10.5 fl oz	12	7
	(Sivanto Prime)	7–14 fl oz	12	7
	MODE-OF-ACTION GROUP NUMBER[1]: 4D			
	COMMENTS: Do not apply more than 28.0 fl oz of Sivanto Prime or 200SL (0.365 lb flupyradifurone)/acre per calendar year on alfalfa, regardless of product or formulation. Highly toxic to adult alfalfa leafcutting bee via direct contact exposure. Do not apply to foliage when managed alfalfa leafcutting bees are foraging in the treatment area.			
B.	PERMETHRIN			
	(Pounce 25WP)	6.4–12.8 oz	12	See label
	MODE-OF-ACTION GROUP NUMBER[1]: 3A			
	COMMENTS: Do not apply when bees are present.			
C.	DIMETHOATE			
	(Dimethoate 400 EC)	0.5–1 pt	48	10
	MODE-OF-ACTION GROUP NUMBER[1]: 1B			
	COMMENTS: Do not apply when bees are present.			
D.	ZETA-CYPERMETHRIN			
	(Mustang)	2.4–4.3 fl oz	12	See comments
	MODE-OF-ACTION GROUP NUMBER[1]: 3A			
	COMMENTS: Preharvest interval is 3 days for cutting and grazing and 7 days for seed.			
E.	METHOMYL*			
	(Lannate LV)	1.5–3 pt	48	7
	(Lannate SP)	0.5–1 pt	48	7
	MODE-OF-ACTION GROUP NUMBER[1]: 1A			
	COMMENTS: Do not apply when bees are present.			
F.	LAMBDA-CYHALOTHRIN			
	(Warrior II with Zeon)	0.96–1.6 fl oz	24	See comments
	MODE-OF-ACTION GROUP NUMBER[1]: 3A			

COMMENTS: Preharvest interval (PHI) is 1 day for forage and 7 days for hay. Do not apply when bees are actively foraging.

G.	BETA-CYFLUTHRIN (Baythroid XL)	see label	12	7

MODE-OF-ACTION GROUP NUMBER[1]: 3A

COMMENTS: Can be disruptive to natural enemies. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

** 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 personal protective equipment. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

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

1 Group numbers for insecticides and miticides are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides 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. For more information, see irac-online.org.

MORMON CRICKET (1/17)

Scientific Name: *Anabrus simplex*

DESCRIPTION OF THE PEST

Mormon crickets are not true crickets but more closely related to katydids and longhorned grasshoppers. They pass the winter as eggs in the soil, preferring barren, sandy soil in sunny locations. Eggs hatch in the first warm days of spring and the crickets pass through seven nymphal stages in about 75 to 100 days. Mature adult female crickets lay eggs throughout the summer, but the eggs don't hatch until the following spring.

Adults are about 1 inch, heavy-bodied, and tan colored. The wings are small and useless; these insects do not fly. The antennae are as long as the body, and the female has a sword-shaped ovipositor also as long as the body. Mormon crickets are active only during the warm, sunny part of the day and seek shelter at night or in cloudy or rainy weather. When they are half grown, they begin migrating from their rangeland breeding grounds. The migrations occur at air temperatures of 65 to 95°F and when winds are less than 25 mile per hour.

They can be a pest of the Low Desert areas.

DAMAGE

Mormon crickets become pests very sporadically (about once or twice in a decade) when numbers build to high levels and they migrate over large areas. If an alfalfa field is in the path of a migration, Mormon crickets can cause severe damage by devouring the plants.

MANAGEMENT

Management of Mormon crickets centers on preventing invasions of fields with barriers or insecticide baits.

Cultural Control

Because these insects cannot fly, linear barriers of 10-inch strips of 28- to 30-gauge galvanized iron, held on edge with stakes driven into the ground may stop swarms. Soil pits or water traps may be made at intervals to catch crickets halted by the barrier.

Organically Acceptable Methods

Cultural controls are acceptable for use on an organically certified crop.

Monitoring and Treatment Decisions

Treatments on the border of the field may be effective at limiting invasion of migrating populations of this pest; baits work well for this purpose. Check with your county agricultural commissioner regarding the current registration of baits to control Mormon crickets in alfalfa fields.

PALE-STRIPED FLEA BEETLE (1/17)

Scientific Name: *Systena blanda*

DESCRIPTION OF THE PEST

Flea beetle adults are small (about 0.12 inch), shiny beetles with enlarged hind legs that allow them to jump like fleas. The pale-striped flea beetle has a broad white stripe down each brown wing. Flea beetles can overwinter on weed hosts surrounding fields and in soil and plant residues of previous susceptible crops such as tomatoes and other fruit and vegetable field crops.

DAMAGE

Adult flea beetles do most of the damage by feeding on the undersides of leaves, leaving small pits or irregularly shaped holes on the leaves. Large numbers of flea beetles can kill or stunt seedlings. Older plants rarely suffer economic damage although their older leaves may be damaged. The small, slender, white flea beetle larvae feed on underground parts of the plant, but this damage is not economically significant. Outbreaks of flea beetles in alfalfa seedling fields have occurred in the Central Valley in the fall, but these beetles are also active during springtime

MANAGEMENT

Cultural Control

Adult flea beetles overwinter in plant debris. To destroy possible refuge sites of adult flea beetles, maintain field sanitation by keeping field margins free from weeds. In case of infested fields, deeply disc plant residue after harvest. Crop rotation with nonhost plants (e.g., cereal grains such as wheat) and maintaining good plant health (e.g., no water stress) are also important for managing flea beetles in alfalfa production.

Organically Acceptable Methods

Only cultural controls are available for this pest on organically grown alfalfa.

Monitoring and Treatment Decisions

Check newly emerged seedlings weekly for flea beetle damage until plants are well established, especially if there was a flea beetle problem in the previous crop. Sometimes infestations can be spotty, for example on field edges when they migrate into alfalfa stands. Relatively low numbers can cause economic damage when plants are in the cotyledon or first-leaf stages. Treat if you find that the flea beetles are causing stand loss. Alfalfa seedling fields need at least 10 to 20 plants per square foot to ensure a viable stand at the end of the first year of production.

Once plants have several true leaves, they can tolerate several beetles per plant without damage. Older plants are even more tolerant. Insecticide applications should rarely be required, but if it is, one application should suffice. However, insecticides may disrupt biological control of aphids, which are increasingly becoming a problem in alfalfa production. Spot treatment of infested areas may be warranted where stand loss is occurring in certain areas of the field, for example on field edges.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least 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. BETA-CYFLUTHRIN
(Baythroid) — Label rates — 12 — 7
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Do not spray directly or allow drift onto blooming crops or weeds where bees are foraging.

B. LAMBDA-CYHALOTHRIN*
(Warrior II with Zeon) — Label rates — 24 — 1 (forage), 7 (hay)
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Do not spray directly or allow drift onto blooming crops or weeds where bees are foraging.

** 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 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). For additional information, see their website at http://irac-online.org/.

PEA APHID (1/17)

Scientific Names: Pea aphid: *Acyrthosiphon pisum*

DESCRIPTION OF THE PESTS

(View photos online to identify aphids)
The pea aphid is a large green aphid with long legs, antennae, cornicles, and cauda. It is very similar in appearance to the blue alfalfa aphid, but they can be distinguished by examining the antennae. The antennae of the pea aphid have narrow dark bands on each segment, whereas those of the blue alfalfa aphid gradually darken to brown as you near the tip of the antennae.

A pink biotype of the pea aphid has been found in California. Except for its pink color, it is identical in appearance to the green biotype. The pink biotype causes similar damage to the green pea aphid and management practices are the same, but some studies have suggested it may be partially resistant to parasitization by *Aphidius ervi* and may also circumvent some of the pea aphid resistance bred into many alfalfa cultivars.

Both the blue alfalfa aphid and the two strains of the pea aphid prefer cooler temperatures (optimal temperature for development of both blue alfalfa and pea aphid is around 60°F) and reach damaging levels in spring. However blue alfalfa aphid is more tolerant than pea aphid of cool temperatures and appears earlier in the late winter and early spring. Pea aphid populations often reoccur in fall. In the spring, pea aphids are often present in alfalfa fields at the same time as the alfalfa weevils. Blue alfalfa aphid colonizes the plant terminals while pea aphid is usually more generally distributed. Both species prefer to feed on the stems rather than the leaves.

DAMAGE

As aphids feed on alfalfa, they inject a toxin into the plant. This toxin can have damaging effects on plant growth. Of the four aphid species that infest alfalfa (pea aphid, blue alfalfa aphid, cowpea aphid and spotted alfalfa aphid), the pea aphid has the least damaging toxin to alfalfa. While the number of pea aphids feeding on the plants can cause damage by removing plant sap (photosynthates), the pea aphid toxin itself is not particularly damaging to alfalfa plants.

A black fungus, sooty mold, also grows on the honeydew excreted by the aphid. This reduces palatability to livestock. Damage is more severe on short alfalfa than taller alfalfa

MANAGEMENT

Using resistant varieties of alfalfa and encouraging populations of natural enemies are important in managing pea aphid. It is important to distinguish between the pea and blue alfalfa aphids because blue alfalfa aphid causes more damage than pea aphid, and the two species have different treatment thresholds. Natural enemies, especially lady beetles, are monitored along with the aphids to determine the need for a pesticide application. Aphids frequently become problems when weevil sprays kill their natural enemies. Border harvesting or strip cutting can be important for preserving natural enemies.

Resistant Varieties

Planting alfalfa varieties resistant to pea aphid has been the most effective means of controlling these aphids in alfalfa. Studies in the eastern U.S. have shown that the pink biotype of the pea aphid has overcome resistance in a number of cultivars with the exception of CUF 101. When selecting varieties, consult your farm advisor for information on resistant varieties suited to your area, or check a list of

alfalfa varieties provided by the National Alfalfa & Forage Alliance. Additionally, a yearly alfalfa variety report can be found at http://alfalfa.ucdavis.edu.

Biological Control

(View photos online of natural enemies)

The most significant aphid predators are several species of lady beetles, including *Hippodamia convergens* and *Coccinella septempunctata* that attack and consume both pea and blue alfalfa aphids; treatment thresholds for pea aphid are based on the number of lady beetle adults and larvae present. Green lacewings can also be important in regulating aphids and many other predators including bigeyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.), and syrphid fly larvae also play a role.

The major parasites of the pea aphid are *Aphidius smithi* and *A. ervi*. However, several studies have suggested that the pink biotype of pea aphid shows signs of partial resistance to *A. ervi.* Large golden-brown aphid mummies on the upper surfaces of leaves indicate parasitization. If parasites are present in high numbers, consider this when making your pesticide application decision since parasites frequently provide adequate control.

A naturally occurring fungal disease, which is most prevalent during cool, rainy, or foggy weather, may also control aphids.

Cultural Control

Use border-strip cutting during harvest to help maintain populations of parasites and predators within the field. For more details, see BORDER-STRIP HARVESTING.

Organically Acceptable Methods

The use of resistant varieties, biological control, and cultural control are acceptable to use on an organically certified crop. Organically certified insecticides such as azadirachtin (Neemix), neem oil (Trilogy), and pyrethrin (PyGanic) are registered for use on alfalfa to control aphids. Studies conducted in California, however, have shown that at best they provide some suppression of aphids but do not control them.

Monitoring and Treatment Decisions

Start to monitor fields in February for pea aphid and continue monitoring through spring. In fall, resume monitoring for pea and blue alfalfa aphids by combining with cowpea monitoring as described in APHID MONITORING.

If natural enemies fail to keep the aphids in check, an insecticide application may be necessary. Economic treatment thresholds for both pea and blue alfalfa aphids are as follows (if both species are present, use the blue alfalfa aphid treatment levels):

Plant height	Pea aphids	Blue alfalfa aphids
Under 10 inches	40 to 50 per stem	10 to 12 per stem
10 to 20 inches	70 to 80 per stem	40 to 50 per stem
Over 20 inches	100 + per stem	40 to 50 per stem

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)

TABLE UPDATED 4/24

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.	FLUPYRADIFURONE			
	(Sivanto 200SL)	7–10.5 fl oz	12	7
	(Sivanto Prime)	7–14 fl oz	12	7
	MODE-OF-ACTION GROUP NUMBER[1]: 4D			
	COMMENTS: Do not apply more than 28.0 fl oz of Sivanto Prime or 200SL (0.365 lb flupyradifurone)/acre per calendar year on alfalfa, regardless of product or formulation. Highly toxic to adult alfalfa leafcutting bee via direct contact exposure. Do not apply to foliage when managed alfalfa leafcutting bees are foraging in the treatment area.			
B.	FLONICAMID			
	(Beleaf 50SG)	2.8 oz	12	14
	MODE-OF-ACTION GROUP NUMBER[1]: 29			
	COMMENTS: Use allowed under a 24c registration (SLN CA-140006).			
C.	DIMETHOATE			
	(Dimethoate 2.67EC)	0.75–1.5 pt	48	See comments
	MODE-OF-ACTION GROUP NUMBER[1]: 1B			
	COMMENTS: Check label to see if product allows only one application per year or per cutting. Preharvest interval (PHI) is 10 days for harvest or pasturing; for alfalfa seed: do not feed or graze livestock on treated crops, hay threshings, or stubble within 20 days of application. Do not apply when bees are present.			
D.	MALATHION			
	(Malathion 8-E)	1–1.25 pt	12	0
	MODE-OF-ACTION GROUP NUMBER[1]: 1B			
	COMMENTS: *Use only when other products cannot be used.* Do not apply when bees are present.			

** 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 personal protective equipment. 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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SPIDER MITES (1/17)

Scientific Names: Twospotted spider mite: *Tetranychus urticae*
Spider mites: *Tetranychus* spp.

DESCRIPTION OF THE PEST

Spider mites are small pests, with adults about the size of a small pinhead, variable in color (green or yellow) with dark pigmented spots. Adult spider mites have eight legs and are oblong to spherical in shape. The eggs of spider mite species found in alfalfa are very small, whitish, and spherical in shape. You will need a hand lens to see them.

Spider mites are usually found on the undersides of leaves, with colonies beginning on the lower (older) leaves and moving upward on the plant.

DAMAGE

Spider mite feeding first appears as stippling (small yellow areas) on leaves. Severe damage desiccates leaves, and they may fall from the plants. Heavily infested plants may be stunted and have a yellowish appearance. Tonnage reduction of almost 0.2 tons of hay per acre has been documented in the low desert from severe spider mite infestations. Reductions are thought to be greatest when alfalfa is growing slower and infestations occur early in the cutting cycle.

MANAGEMENT

Spider mite infestations may occur in any alfalfa-growing area, but damage and yield losses are most common in the low desert production areas of Imperial and Riverside counties. Spider mite infestations in the Central Valley are rare and can usually be managed by a timely irrigation. Infestations and losses are most closely associated with bedded alfalfa production.

In the low desert, spider mites have been most damaging from March through May. More than one cutting may be affected. On bedded alfalfa, spider mites build up on weeds during the early spring and as the weeds dry up spider mites move onto the alfalfa. This is generally not a problem on solid-planted alfalfa grown in the Central Valley or the Intermountain counties.

Control options for spider mites in alfalfa include:

- weed management,
- proper irrigation and fertilization to minimize plant stress,
- timely harvest, and
- chemical control.

Biological Control

Western flower thrips are often an effective predator of spider mites, migrating into alfalfa from surrounding crops as their host plants desiccate. Spider mites are also fed on by minute pirate bugs, big-eyed bugs, and lacewing larvae.

Cultural Control

In the low desert, an important component of mite management is to control weeds along field edges during the winter to eliminate potential host plants that can serve as overwintering sites and initial locations of spider mite infestations. Since water-stressed alfalfa is more prone to infestation than non-

stressed alfalfa, a timely irrigation will often alleviate the problem. Minimizing plant stress through improved irrigation, fertilization, and cultural practices such as timely harvests is also beneficial.

Organically Acceptable Methods

Clarified extract of neem oil (Trilogy) can effectively control spider mites. Best results are noted when the alfalfa plant is short, allowing for more thorough spray coverage.

Monitoring and Treatment Decisions

Look for spider mites on the undersides of leaves. Treatment thresholds have not been established, but pesticide applications may be economically justified in alfalfa grown for hay when:

- spider mites are present and cutting cycles are longer than 30 days (more defoliation of lower leaves and quality reduction) or
- regrowth is being hindered and the field has been monitored to confirm spider mites are the cause of the slow growth.

Low Desert Areas

Reinfestations are usually not severe when temperatures are 108ºF (or higher) or when alfalfa is green-chopped and moved immediately from the field. If fields of susceptible crops (such as cotton, melons) are adjacent to spider mite-infested alfalfa, they may become infested when the alfalfa is harvested if spider mites migrate from the drying plants. In these situations it may be necessary to apply a pesticide to the adjacent crop to protect it from migrating mites; a pesticide application to the field's border may be adequate.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least 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. HEXYTHIAZOX (Onager)	10–24 oz	12	14
MODE OF ACTION: 10A COMMENTS: A growth regulator that is a contact toxin to eggs and juveniles. Adult mites are not directly affected, but it causes adult females to lay sterile eggs.			
B. CLARIFIED EXTRACT OF NEEM OIL# (Trilogy)	32 oz	4	0
MODE OF ACTION: Unknown. A botanical insecticide. COMMENTS: Can be applied at cutting. Thorough coverage is essential for good control.			

** 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.

Acceptable for use on an organically grown crop.

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). For additional information, see their website at http://irac-online.org/.

SPOTTED ALFALFA APHID (1/17)

Scientific Name: *Therioaphis maculata*

DESCRIPTION OF THE PEST

(View photos online to identify aphids)
The spotted alfalfa aphid is a small, pale yellow or grayish aphid with four to six rows of spined black spots on its back. Mature females may either be wingless or have wings with smoky areas along the veins. This aphid prefers warm weather and is generally found during summer months. In the southern desert, high numbers may continue into fall and winter.

DAMAGE

Spotted alfalfa aphids inject a toxin into the plant as they feed. Severe aphid infestations stunt plants, reduce yield, and may even kill plants. These aphids also secrete large quantities of honeydew. Plants become very sticky at relatively low aphid densities, and a black fungus that grows on the honeydew excreted by the aphid reduces palatability to livestock and lowers the alfalfa's feeding value.

MANAGEMENT

Use resistant varieties and encourage natural enemies to help control spotted alfalfa aphids. Border harvesting or strip cutting can be important for preserving natural enemies. In the event that host plant resistance fails or natural enemies do not hold aphid numbers below economic threshold levels, insecticide applications may be necessary.

Resistant Varieties

Planting alfalfa varieties resistant to spotted alfalfa aphid has been the most effective means of controlling these aphids in alfalfa. However, biotypes of spotted alfalfa aphid that are capable of infesting previously resistant varieties are constantly evolving, and even fields planted to resistant varieties should be checked frequently. When selecting varieties, consult your farm advisor for information on varieties suited to your area, or check a list of alfalfa varieties provided by the National Alfalfa & Forage Alliance. Available online at: http://alfalfa.org. Additionally, a yearly alfalfa variety performance report can be found at http://alfalfa.ucdavis.edu.

Biological Control

(View photos online of natural enemies)
Common reddish lady beetles, including the convergent lady beetle, attack and consume this aphid. Green lacewings can also be important in regulating aphids and many other predators including bigeyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.), and syrphid flies also play a role.

An introduced parasite, *Trioxys complanatus*, has become established on the spotted alfalfa aphid. Brown aphid mummies attached to leaves and stems of alfalfa plants indicate the presence of this parasite. Caution should be exercised in spraying for aphids when the parasite is present.

Cultural Control

Use border-strip cutting during harvest to help maintain populations of parasites and predators within the field. For more details, see BORDER-STRIP HARVESTING.

Organically Acceptable Methods

The use of resistant varieties and biological and cultural controls are acceptable to use on an organically certified crop. Organically certified insecticides such as azadirachtin (Neemix), neem oil (Trilogy), and

pyrethrin (PyGanic) are registered for use on alfalfa to control aphids, but studies have not been conducted in California to determine their effectiveness.

Monitoring and Treatment Decisions

It is important to sample all fields, even those with resistant varieties, frequently during periods of maximum aphid activity. Start sampling for spotted alfalfa aphid in June and continue until fall. To combine monitoring with cowpea aphid, see APHID MONITORING.

In addition to monitoring aphids, also take sweep net samples for lady beetles and record all counts on a monitoring form *(available online)*.

Spotted Alfalfa Aphid Treatment Thresholds

Time of occurrence	No. of aphids per stem
Spring months	40 aphids per stem*
Summer months	20 aphids per stem*
After last cutting in the fall	50 to 70 aphids per stem
Newly seeded alfalfa in lower desert	20 aphids per stem
***Do not apply a pesticide if the ratio of lady beetles to aphids is equal to or exceeds the following:**	
No. of lady beetles per sweep	**No. of aphids per stem**
ON STANDING ALFALFA	
1 or more adults	5 to 10 aphids
3 or more larvae	40 aphids
ON STUBBLE	
1 or more larvae	50 aphids

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least 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.

The following pesticides have not been tested under California conditions but have been found to be effective in other areas.

A. FLUPYRADIFURONE

(Sivanto 200SL)	7–10.5 fl oz	12	7
(Sivanto Prime)	7–14 fl oz	12	7

MODE-OF-ACTION GROUP NUMBER[1]: 4D

COMMENTS: Do not apply more than 28.0 fl oz of Sivanto Prime or 200SL (0.365 lb flupyradifurone)/acre per calendar year on alfalfa, regardless of product or formulation.

B. DIMETHOATE

(Dimethoate 2.67EC)	Label rates	48	See comments

MODE-OF-ACTION GROUP NUMBER[1]: 1B

COMMENTS: Check label to see if product allows only one application per year or per cutting. Preharvest interval (PHI) is 10 days for harvest or pasturing; for alfalfa seed: do not feed or graze livestock on treated crops, hay threshings, or stubble within 20 days of application. Do not apply when bees are present.

C. MALATHION

(Malathion 8-E)	1–1.25 pt	12	0

MODE-OF-ACTION GROUP NUMBER[1]: 1B

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

COMMENTS: *Use only when other products cannot be used.* Do not apply when bees are present.

‡ 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 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). For additional information, see their website at http://irac-online.org/.

SWEETPOTATO WHITEFLY (1/17)

Scientific Names: *Bemisia tabaci* MEAM1 (formerly B biotype)

DESCRIPTION OF THE PEST

Sweetpotato whitefly adults are tiny 0.06 inch (1.5 mm), yellowish insects with white wings. Their wings are held somewhat vertically tilted, or rooflike, over the body and generally do not meet over the back but have a gap separating them. Another species that may be present, bandedwinged whiteflies (*Trialeurodes abutiloneus*), have brownish bands across their wings.

Whiteflies are found mostly on the undersides of leaves. They fly readily when plants are disturbed. The tiny, oval eggs hatch into a first nymphal stage that has legs and antennae and is mobile. The 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.

Last-instar sweetpotato whiteflies are oval and yellowish with red eye spots. The edge of the pupa tapers down to the leaf surface and has few to no long waxy filaments around the edge. In contrast, bandedwinged whitefly nymphs have many long waxy filaments around the edge, and the edge is somewhat vertical where it contacts the leaf surface.

DAMAGE

Whiteflies are sucking insects and their feeding removes nutrients from the plant. As they feed, whiteflies produce large quantities of honeydew that reduce alfalfa hay quality because sooty molds (fungi that produce black spores) often grow on honeydew. Sooty molds are not known to harm cattle or horses, but resemble mold from water-damaged hay that produce toxins. Hay buyers are not likely to buy moldy hay or will discount the price of the hay. Sweetpotato whitefly can cause economic damage to alfalfa in the low desert regions of Southern California and Arizona from July through September.

MANAGEMENT

Research continues to focus on developing commercial cultivars with resistance to whiteflies. If insecticides were registered for whitefly control in alfalfa, they would not be cost effective.

THREECORNERED ALFALFA HOPPER (1/17)

Scientific Name: *Spissistilus festinus*

DESCRIPTION OF THE PEST

The threecornered alfalfa hopper adult is a green, robust, wedge-shaped insect with clear wings. The body is about 0.25 inch (6.4 mm) long, is higher and wider at the head and tapers towards the end. This insect gets its name from the hardened triangular (three-cornered) area over the thoracic area as seen from above. It has piercing-sucking mouthparts. Nymphs are grayish white and soft bodied, with a line of saw-toothed spines on their backs. Adults are mobile whereas nymphs cannot fly and are confined to the lower portions of the plant.

Adults feed on numerous plants and have been recently shown to transmit red blotch in grape vineyards. In alfalfa, threecornered alfalfa hoppers can be found year-round. In the low desert, there are two population peaks for adults: one in late July to early August and a larger second peak in September to early October. In the San Joaquin Valley, threecornered alfalfa hoppers numbers usually peak in late September and October. They are starting to become more numerous in the Sacramento Valley, usually late August to early September. There are three to four generations per year in Southern California.

DAMAGE

Adults and nymphs of the alfalfa hopper usually feed at the base of the alfalfa plant near the crown by inserting their mouthparts into stems and sucking out juices. Injury is also caused when adult female hoppers insert their eggs into stems. Feeding and egg laying can girdle stems, causing the portion of the plant above the girdle to turn red, purple or yellow.

MANAGEMENT

Monitor for adults using a sweep net and by visually watching for stems that show the characteristic reddish discoloring and girdling at the base of the plant. Nymphs are difficult to find because they are at the base of the plant and cannot fly. Occasionally damage is severe enough from the hoppers to justify control measures, especially if other pests, such as armyworm are also injuring the crop. However, this insect does not inject toxins, unlike the *Empoasca*, so they are not as damaging as some leafhopper pests.

Biological Control

Biological control of threecornered alfalfa hopper is generally limited to the first three nymphal instars, which remain inactive lower on the alfalfa plants. Predators include assassin and nabid bugs. Adult hoppers typically escape predation due to their activity and heavy sclerotization (hardening of the exoskeleton), which nymphs lack.

Cultural Control

Overwintering threecornered alfalfa hopper adults and newly hatched nymphs can be found in weedy margins (e.g. vetch) of alfalfa fields in the early spring. Manage these areas to reduce threecornered alfalfa hopper populations that can later migrate into alfalfa fields. Early harvest will also help manage this pest.

Monitoring and Treatment Decisions

No specific threshold numbers have been developed for threecornered alfalfa hoppers. However, in the Sacramento Valley area, an average of four leafhopper adults per sweep over 15 days did not cause economic losses to alfalfa hay; but, in the south valley, 10 to 12 hopper adults per sweep significantly

reduced both alfalfa yield and quality. These numbers give a range of hopper counts for possible injury to the alfalfa crop and should be combined with observations of damage to determine whether to treat with insecticides listed below. Early spring alfalfa stubble insecticide applications after the first cutting are a viable option to manage threecornered alfalfa hoppers long term in outbreak years.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least 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. BETA-CYFLUTHRIN*			
(Baythroid XL)	1.6-2.8 fl oz	12	7
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Do not apply to alfalfa grown for seed because of the potential for injury to bees.			
B. LAMBDA-CYHALOTHRIN*			
(Warrior II with Zeon)	0.96-1.6 fl oz	24	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Preharvest interval (PHI) is 1 day for forage and 7 days for hay. Apply only to fields planted to pure stands of alfalfa. Do not apply when bees are actively foraging.			
C. METHOMYL*			
(Lannate LV)	1.5 pt	48	7
(Lannate SP)	0.5 lb	48	7
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Do not graze or feed livestock for 7 days after application. Do not apply when bees are present.			
D. PERMETHRIN*			
(Pounce 25WP)	6.4–12.8 oz	12	See label
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Do not use more than 0.2 lb a.i./cutting. Do not apply to mixed stands with intentionally grown forage grasses and legumes.			

** 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 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). For additional information, see their website at http://irac-online.org/.

THRIPS (1/17)

Scientific Names: Bean thrips: *Caliothrips fasciatus*

DESCRIPTION OF THE PESTS

Adult bean thrips are minute slender-bodied insects that have a uniformly dark, grayish black body. Their forewings have two dark and two pale bands and visible under magnification, the legs and antennae are also banded light and dark. These should not be confused with the predaceous sixspotted thrips, which are pale-yellow and have six dark spots on the wing covers and primarily feed on mites.

Note: Western flower thrips, *Frankliniella occidentalis*, which vary from yellow to dark brown are very common in alfalfa, but have never been shown to cause economic damage in California. In fact, they often serve as alternate prey for a number of natural enemy species commonly found in alfalfa and they can be effective predators of spider mites.

DAMAGE

Thrips feed by rasping and lacerating the plant tissue and then sucking-up the resulting juices. The rasping causes deformed and crinkled leaves from the uneven growth around the damaged parts of the plant. Feeding, particularly near the leaf mid-rib, causes curling and distortion of the leaves, which often have a cuplike or puckered appearance. Feeding damage also causes light tan spots on the leaf tissue that are accompanied by black fecal spots.

Bean thrips are not economically important pests of established stands, but they can on rare occasions be injurious to seedling stands in October in the low desert alfalfa growing areas. Puckering and stippling of leaves is not a problem. However, if temperatures are high (90ºF+) and plants are water stressed, high numbers of bean thrips along with heavy feeding damage may cause leaf drop. This problem may be worsened by an increased sensitivity to herbicides due to highly stressed plants. Bean thrips may also cause contamination problems (body parts and feces) in adjacent vegetable crops in low desert growing areas when they migrate after the alfalfa hay is cut.

MANAGEMENT

Bean thrips rarely require pesticide applications for control, except perhaps for seedling stands when extensive leaf drop occurs.

WEBWORM (1/17)

Scientific Name: *Loxostege* spp.

DESCRIPTION OF THE PEST

Webworms are greenish black caterpillars over an inch in length, greenish or occasionally brownish orange, with six black spots (tubercles) on each segment, and a stiff hair extending from each tubercle. They are often found within webbed leaves that may be connected to the ground by a silken tunnel through which it will retreat rapidly when disturbed. They vary in size, reaching up to nearly 1.5 inches in length.

Webworms overwinter as larvae in the ground adjacent to their fall food host. Moths emerge in early spring and lay eggs on leaves of host plants. Larvae will feed for 3 to 5 weeks.

DAMAGE

The larval stage feeds inside of webbed leaves on the upper parts of the plant in summer and fall. If numbers are abundant, this webbing will be clearly visible and will cover extensive areas of foliage.

MANAGEMENT

Management of webworms in alfalfa can be achieved by early cutting of the hay if close enough to harvest, because the larvae cannot survive on dried alfalfa. Monitor alfalfa stubble and the new regrowth, especially under the windrows, for 2 to 3 days after cutting. If the webworms are defoliating the stubble after the hay is harvested, an insecticide may be warranted, although a pesticide application is rarely justified in California.

If found in combination with other worms:

- count all larvae from sweep net samples and
- apply a pesticide when there are 10 or more nonparasitized alfalfa caterpillars, armyworms, and webworms combined per sweep.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least 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. METHOXYFENOZIDE (Intrepid 2F)	4–8 fl oz	4	0
MODE-OF-ACTION GROUP NUMBER[1]: 18			
COMMENTS: Make no more than one application per cutting. Not for use in alfalfa grown for seed or for sprouts for human consumption.			
B. INDOXACARB (Steward EC)	6.7–11.3 fl oz	12	7
MODE-OF-ACTION GROUP NUMBER[1]: 22A			
COMMENTS: Highly toxic to bees; do not apply when bees are actively foraging.			

** See label for dilution rates.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)

‡ 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 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). For additional information, see their website at http://irac-online.org/.

WEEVILS (ALFALFA AND EGYPTIAN ALFALFA) (4/24)

Scientific Names: Alfalfa weevil: *Hypera postica*
Egyptian alfalfa weevil: *Hypera brunneipennis*

DESCRIPTION OF THE PESTS

Two identical-looking weevils infest alfalfa in California. In general, they are distinguished by their biology and distribution in the state. The alfalfa weevil has tended to be an annual pest in alfalfa districts east of the Sierra Nevada mountains and in the northernmost counties of California. In most other areas of California (e.g., the intermountain areas) it may have been displaced by the Egyptian alfalfa weevil. The weevils are serious pests due to the lack of natural enemies that can effectively control them, especially the Egyptian alfalfa weevil.

Adult weevils of both species are dark gray and about 0.2 inch. The legless larva of the alfalfa weevil is about 0.25 inch when fully grown. It is pale green with a thin white line down the center of the back and has a brown head. Larvae complete their growth in about 3 to 4 weeks. They will then spin a cocoon and pupate either in the leaves of the plant or on the ground.

Both weevils spend the summer as adults under the loose bark of trees, especially eucalyptus, or in any place they can wedge their bodies, such as in rough-barked trees (walnut) or under shake shingles on homes.

Alfalfa Weevil

Alfalfa weevil overwinters as an adult in field trash or other secluded hiding places and emerges in late winter or early spring. Soon after emergence and mating, the adult females begin inserting their eggs into the alfalfa stems. Hatching larvae make their way up the stem to feed on alfalfa terminals and drop to spin a cocoon and pupate by early summer. This species generally has only one generation a year.

Egyptian Alfalfa Weevil

In late fall or early winter, Egyptian alfalfa weevils migrate to alfalfa fields. Soon after entering the fields, adult females begin inserting their eggs into the stems of alfalfa, and hatching larvae make their way into the alfalfa terminals. Egyptian alfalfa weevil may be found in the field throughout the year, although damage is most serious in spring. This species usually has one generation, but a smaller second generation has been documented in the southern San Joaquin Valley.

DAMAGE

Young larvae damage alfalfa by feeding on terminal buds; larger larvae feed on the leaflets. Feeding by older larvae is the most damaging and is characterized as skeletonization and bronzing of the leaves in spring. Under severe pressure, complete defoliation can occur. Damage from both weevils is most commonly seen before the first cutting. However, if weevil damage continues after the first cutting, Egyptian alfalfa weevil is more likely to cause significant damage to the second cutting (and occasionally the third cutting) than alfalfa weevil.

Adult weevils feed on alfalfa but generally do not cause significant damage.

MANAGEMENT

Weevil management in alfalfa is focused on the period before the first cutting. Control options are insecticides and early harvest. Biological control is not effective at preventing economic damage in most areas because populations of natural enemies are not sufficient to provide control in the spring.

Biological Control

Alfalfa weevils have natural enemies, but they are not effective enough to provide good control early in the season when most needed. Two parasitic wasps, *Bathyplectes curculionis* and *Bathyplectes anurus*, have been introduced into California for control of the larval stage of the alfalfa weevil and the Egyptian alfalfa weevil. *Bathyplectes curculionis* is present throughout the range of both alfalfa weevil species in California. It can provide up to 30% parasitism of larvae late season but is frequently encapsulated and killed by the Egyptian strain. *Bathyplectes anurus* has become established in Central Valley alfalfa as well as other locations; however, at the present time it is only found at very low levels. *Microctonus aethiopoides*, a parasite of the adult weevil, was established and had been recovered from some counties in California in the past, but recent studies indicate that the parasite is absent or present at very low levels throughout the state and does not provide adequate weevil control. The parasitoid *Oomyzus incertus* is very effective, with up to 50% parasitism of the weevil larvae late season, which, together with *B. curculionis*, likely explains the smaller second generation, as appears to be under good biocontrol.

An alfalfa weevil-specific fungus occurs in many alfalfa-growing regions in California that aids in biological control. This soil-dwelling fungus (*Zoophthora phytonomi*) sporulates and infects the larval stage, causing death of weevil larvae within days of infection, providing up to 30% weevil suppression. In some regions in California, the fungus maintains numbers of weevils below the economic threshold of 20 per sweep and may help minimize the need to apply a pesticide for the weevil. However, the fungus infection level depends on sustained soil moisture—in dry years there is little infection.

Cultural Control

After alfalfa weevil larvae begin to appear, check fields at 2- to 4-day intervals. Cutting the crop as soon as most of the plants are in the bud stage can sometimes prevent serious damage by the weevil. Also, the process of harvesting and curing the alfalfa kills most weevils. However, early cutting to control weevils concentrates the survivors in the windrows. Closely monitor alfalfa regrowth for the second cutting to detect feeding damage because both larvae and adults can cause injury.

Organically Acceptable Methods

The primary organically acceptable management method is cutting the crop early if damage seems imminent. Sprays of the Entrust formulation of spinosad are also acceptable to use on an organically certified crop.

Monitoring and Treatment Decisions

- Begin monitoring for weevils in early January in southern and central areas of the state and in April in the far northern intermountain area. If the alfalfa is too short to sweep, look for signs of feeding damage on the leaves.
- Sweep fields with adequate plant height weekly after weevil larvae begin to appear in late winter or early spring. Take five sweeps in four sections of the field.
- As thresholds are approached, monitor every 2 to 4 days to determine if numbers decline or a pesticide application is required. (For details on sweep net sampling, see Sampling with a Sweep Net.)
- Record your observations on a monitoring form *(available online)*. Research is underway to reevaluate threshold levels, but currently the recommendation is that a pesticide application is warranted when the weevil larvae count reaches an average of 20 or more larvae per sweep.
- Continue to monitor weekly:

- Central Valley: typically late winter through early spring or after a pesticide application (occasionally a second generation can carry into late spring).
- Southern deserts: January through March.
- Northern intermountain areas: mid- April through early-June.

In some situations early harvest can be used to manage larval numbers when they reach damaging levels. This tactic minimizes the killing of predators and parasites of aphid pests by pesticides. However, before making a decision to harvest early, consider stand vigor and economic practicality.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least 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. INDOXACARB
(Steward EC) — 6.7–11.3 fl oz — 12 — 7
MODE-OF-ACTION GROUP NUMBER[1]: 22A
COMMENTS: Make no more than one application per cutting. Do not apply when bees are in the area. Steward EC can be used for alfalfa grown for seed, but seeds cannot be used for sprouts intended for human consumption or livestock feed. All seed must be tagged, "Not for human or animal use."

B. LAMBDA-CYHALOTHRIN
(Warrior II with Zeon) — 1.28–1.92 fl oz — 24 — See comments
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Preharvest interval (PHI) is 1 day for forage and 7 days for hay. Some weevil populations in the Intermountain and Low Desert production areas developed resistance to lambda-cyhalothrin. Do not apply when bees are actively foraging.

C. BETA-CYFLUTHRIN
(Baythroid XL) — 1.6–2.8 fl oz — 12 — 7
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Not for use in alfalfa grown for seed. Some weevil populations in the Intermountain and Low Desert production areas developed cross-resistance to beta-cyfluthrin. Can be disruptive to natural enemies. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

D. MALATHION
(Malathion 8-E) — 1–1.25 pt — 12 — 0
MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: *Use only when other products cannot be used.* Do not apply when bees are present.

E. SPINOSAD
(Entrust SC)# — 2–4 fl oz — 4 — See comments
MODE-OF-ACTION GROUP NUMBER[1]: 5
COMMENTS: Preharvest interval (PHI) is 0 days for forage and 3 days for hay and fodder.

** 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 personal protective equipment. 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 for insecticides and miticides are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides 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. For more information, see irac-online.org.

Acceptable for use on certified organic crops.

WESTERN YELLOWSTRIPED ARMYWORM (1/17)

Scientific Name: *Spodoptera praefica*

DESCRIPTION OF THE PEST

Western yellowstriped armyworm may be abundant in alfalfa fields in the Central Valley from June to early September.

The caterpillar is usually black, with two prominent stripes and many narrow bright ones on each side. At maturity it is approximately 1.5 to 2 inches long. Eggs are laid in clusters on the upper side of leaves and covered with a gray, cottony material. Eggs hatch in a few days and larvae reach full size in 2 to 3 weeks. Larvae pupate on or just under the soil surface. Adults are brown moths that primarily fly at night but may be encountered flying up as you walk through the field.

There are at least five generations per year in the low desert and four generations in the Central Valley.

DAMAGE

Armyworms skeletonize leaves, leaving veins largely intact.

MANAGEMENT

Armyworms are frequently controlled by natural enemies and are more or less cyclic, occurring in large numbers only every few years. Early harvest, border cutting and biological control are important management methods that prevent damage from armyworms.

Biological Control

Natural enemies can provide good control of armyworms in many fields. Predators include bigeyed bugs, spiders, minute pirate bugs, damsel bugs, and lacewings. The parasitic wasp, *Hyposoter exiguae*, is believed to be the most important of at least 10 parasites attacking this pest. Sample for parasitism by pulling the heads from older caterpillars and squeezing the body contents out toward the head end. *Hyposoter* larvae are a light, translucent green color. Viral diseases can also be important.

Cultural Control

Fields may be cut to avoid damage.

Organically Acceptable Methods

Biological and cultural control methods, as well as sprays of *Bacillus thuringiensis* (e.g., Xentari), are acceptable for use on an organically certified crop.

Monitoring and Treatment Decisions

(View photos online for identification of caterpillars)
In early summer start sweeping fields with adequate plant height 2 to 3 times per week to monitor for caterpillars; monitoring can be discontinued after September. Divide each field into 4 sections and take 5 sweeps per section with a 15-inch diameter sweep net, for a total of 20 sweeps. For information on sampling, see SAMPLING WITH A SWEEP NET.

Combine monitoring of armyworms with monitoring for alfalfa caterpillars and leafhoppers as described in ALFALFA CATERPILLAR AND ARMYWORM MONITORING. Count and record the number of healthy and parasitized caterpillars caught in your sweep net on a monitoring form *(available online)*.

If cutting is not practical or not scheduled soon after monitoring, apply a pesticide if there is an average of:

- 10 or more nonparasitized alfalfa caterpillars per sweep,
- 15 or more nonparasitized armyworms per sweep, or
- 10 or more nonparasitized alfalfa caterpillars and armyworms combined per sweep.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)

TABLE UPDATED 4/24

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.	METHOXYFENOZIDE (Intrepid 2F) MODE-OF-ACTION GROUP NUMBER[1]: 18 COMMENTS: Make no more than one application per cutting. Not for use in alfalfa grown for seed or for sprouts for human consumption.	4–8 fl oz	4	see label
B.	CHLORANTRANILIPROLE (Vantacor) MODE-OF-ACTION GROUP NUMBER[1]: 28 COMMENTS: Make no more than one application per cutting. To reduce the development of resistance, do not make more than two applications of any group 28 insecticides in a crop year.	1.2–2.5 fl oz	4	0
C.	INDOXACARB (Steward EC) MODE-OF-ACTION GROUP NUMBER[1]: 22A COMMENTS: Make no more than one application per cutting. Steward EC can be used for alfalfa grown for seed, but seeds cannot be used for sprouts intended for human consumption or livestock feed. All seed must be tagged: "Not for human or animal use."	9.2–11.3 fl oz	12	7
D.	BACILLUS THURINGIENSIS ssp. AIZAWAI (XenTari)# MODE-OF-ACTION GROUP NUMBER[1]: 11A COMMENTS: Apply when larvae are small (in first or second instar). Does not harm beneficial insects. Repeat the application as necessary.	0.5–2 lb	4	0

** 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 personal protective equipment. 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 for insecticides and miticides are assigned by the Insecticide Resistance Action Committee (IRAC). Rotate pesticides 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. For more information, see irac-online.org.

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

\# Acceptable for use on an organically grown crop.

Diseases

(Section reviewed 3/17)

ALFALFA DWARF (3/17)

Pathogen: *Xylella fastidiosa*

SYMPTOMS AND SIGNS

The primary symptom of plants infected with the bacterium *Xylella fastidiosa* is stunted regrowth after cutting. The stunting may not be apparent for many months after initial infection. Leaflets on affected plants are smaller, often a slightly darker (bluish) color but not distorted, mottled, or yellow. The taproot is normal sized, but slicing it diagonally or horizontally down the root reveals abnormally yellowish wood with fine dark streaks of dead tissue. In recently infected plants, the yellowing is mostly in a ring beginning under the bark, with a normal white cylinder of tissue in the center. The inner bark is not discolored, there are no gummy pockets underneath the bark, and there are no large brown or yellow patches as is the case with bacterial wilt caused by *Clavibacter insodiosum*. Dwarf disease progressively worsens over 1 to 2 years after first symptoms and eventually kills the plant.

COMMENTS ON THE DISEASE

Sharpshooters are vectors of the bacterium *Xylella fastidiosa*, which causes alfalfa dwarf disease, but only the green and red-headed sharpshooters are known to spread this disease in alfalfa. Other diseases in California caused by this bacterium include Pierce's disease of grapes and almond leaf scorch. Sharpshooters acquire the bacterium while feeding on an infected host plant and spread it to noninfested host plants through subsequent feeding. Sharpshooters continue to be able to transmit the bacterium to plants until they molt.

Alfalfa dwarf has rarely been reported since the 1950s and is primarily distributed only in Southern California and from Madera County south in the San Joaquin Valley. It is not recognized as an economic disease of alfalfa; however, the bacterium that causes alfalfa dwarf, *Xylella fastidiosa*, is the same pathogen that causes Pierce's disease of grapes, a very important grape disease in California. The role that alfalfa plays in the epidemiology of Pierce's disease is important. Leafhoppers, including the blue-green sharpshooter, spread the disease from alfalfa to grapes. Increased levels of Pierce's disease in grapes located adjacent to alfalfa has been documented in the San Joaquin Valley.

MANAGEMENT

To protect grapes, minimize the attractiveness of an alfalfa stand to sharpshooters by preventing the growth of grassy weeds. Green and red-headed sharpshooters require grasses such as bermudagrass, watergrass, cultivated fescues and perennial ryegrass to breed. Annual grass weeds or cover in orchards and vineyards do not seem to develop significant numbers of sharpshooters if weeds are removed at least annually. This practice will reduce the transfer of the bacterial pathogen between alfalfa and grape vineyards.

When possible, avoid planting alfalfa adjacent to grape vineyards in areas where Pierce's disease is prevalent

ALFALFA MOSAIC AND CUCUMBER MOSAIC (3/17)

Pathogens: *Alfalfa mosaic virus* (AMV)
Cucumber mosaic virus (CMV)

SYMPTOMS AND SIGNS

Alfalfa mosaic virus may cause yellow mottling or streaking on leaves, but at other times the symptoms are masked and leaves appear normal.

Cucumber mosaic virus shows no symptoms in alfalfa.

COMMENTS ON THE DISEASES

These viruses have not been proven to be of economic importance in California alfalfa production. However, aphids that feed on alfalfa and then move to other crops may transmit these viruses to economically important crops. For example, alfalfa mosaic virus can cause economic losses in tomatoes and potatoes. Cucumber mosaic virus is one of several viruses that cause plant death in garbanzo beans grown in the San Joaquin Valley.

MANAGEMENT

No management is suggested.

AIR POLLUTION (3/17)

Pathogen: none (abiotic disorder)

SYMPTOMS AND SIGNS

High levels of ozone cause a bleached stippling on upper leaf surfaces. Symptoms usually appear on middle-aged and older leaves. Affected leaves may age rapidly and fall off. High concentrations of ozone are associated with low wind velocities and bright sunlight.

Symptoms of peroxyacetyl nitrate on alfalfa leaves resemble those described for ozone injuries but the lesions may be larger. A silver or copper sheen is frequently apparent on affected leaves.

COMMENTS ON THE DISEASE

Crop injury from air pollutants results in reduced photosynthetic rates and early aging, which adversely affect crop yield and quality. Many air pollutants (e.g., ammonia, chlorine, hydrogen chloride, hydrogen fluoride, or sulfur dioxide) are capable of causing plant damage, but only the photochemical oxidants (ozone and peroxyacetyl nitrate) are of major concern. They are formed by the reactions of oxygen, nitrogen oxides, and organic molecules in the presence of sunlight. The primary source for these compounds is automobile exhaust, but industrial processes and other forms of combustion contribute to air pollution.

ANTHRACNOSE (3/17)

Pathogen: *Colletotrichum trifolii*

SYMPTOMS AND SIGNS

Anthracnose can affect leaves and stems, but crown rot is the most important phase of the disease. The most obvious symptom is the bluish-black, V-shaped rot in the crown. Dead stems associated with such crowns are sometimes bleached white. Because stems die suddenly, the dead leaves do not drop from the stem.

Anthracnose also causes small, irregularly shaped blackened areas on stems that become large, oval, or diamond-shaped straw-colored lesions with black borders. Black fruiting bodies (acervuli), which under a hand lens look like small dots, develop in the lesion. As lesions enlarge, they may coalesce, girdle, and kill affected stems, sometimes resulting in a characteristic "shepherd crook" on top of stem. In summer and fall, dead shoots (light in color) are scattered throughout the field.

COMMENTS ON THE DISEASE

Anthracnose is a common problem in older alfalfa stands. The fungus persists in alfalfa debris and crowns. The disease reaches maximum severity during late summer and early fall coincident with warm and humid weather. During the growing season, spores on stem lesions are a source of inoculum. Splashing rain and irrigation water disperse spores onto growing stems and petioles. Spores may also be spread with seed contaminated during the threshing process.

MANAGEMENT

Control of anthracnose involves use of resistant cultivars or cultural practices. Cultivars resistant to Anthracnose are listed in the National Alfalfa & Forage Alliance website, available online at: http://alfalfa.org. Start looking for signs of anthracnose in early summer.

Rotation with crops other than clover and alfalfa for at least two years will eliminate sources of inoculum in the field. For more information, see CROP ROTATION.

BACTERIAL WILT (3/17)

Pathogen: *Clavibacter michiganense* ssp *insidiosus* (formerly *Corynebacterium insidiosum*)

SYMPTOMS AND SIGNS

Aboveground symptoms of bacterial wilt include a yellow-green foliage and stunted growth. Leaflets may be mottled and slightly cupped or curled upward. Stems on affected plants may be thin and weak. Disease symptoms are most evident after clipping during regrowth. A cross section of an infected taproot reveals a yellowish-tan color in the center. Brown pockets on the inside of bark tissue are sometimes evident. Once infected, plants do not usually recover. Within 5 to 8 months after showing symptoms, plants usually die. Infected plants are prone to winter kill in areas where soil freezes in winter.

COMMENTS ON THE DISEASE

Bacterial wilt is a warm-season disease that occurs in most areas of California but is rarely seen today because of the development and use of wilt-resistant cultivars in the Sacramento Valley.

The disease is currently not a serious problem in the southern San Joaquin and desert valleys. Symptoms rarely appear before the second or third year of a stand and flood irrigated fields in these areas are typically removed after 3 to 4 years or reseeded for an additional 2 to 3 years. However, subsurface drip irrigated fields may stay in production for up to 5 to 10 years so bacterial wilt may become a problem in the later years of production.

The bacterium survives on plant residues in the soil and enters plants through wounds in the roots and crown or through the cut ends of freshly mowed stems. Disease severity and incidence increase when root-knot nematodes are present. The bacterium can survive in dry plant tissue or seed for at least 10 years and can be disseminated over long distances in seed and dry hay. However, bacteria numbers in the soil decline quickly when infected plant residue decomposes. The bacterium also can be spread by surface water, tillage, mowing, and harvesting equipment. The greatest incidence of the disease occurs in poorly-drained areas of fields, and large areas can be infected during periods of continuous wet weather.

MANAGEMENT

Use resistant cultivars, which are listed in the National Alfalfa & Forage Alliance website. If bacterial wilt is discovered in a field, cut it last during harvest to prevent spread of inoculum by the mower to younger stands. Within a field, harvest infested areas last and never mow when the foliage is wet.

Crop rotation can reduce inoculum in the field. For more information, see CROP ROTATION.

COMMON LEAF SPOT (3/17)

Pathogen: *Pseudopeziza medicaginis*

SYMPTOMS AND SIGNS

Symptoms of common leaf spot include small (0.12 inch), circular, brown-to-black spots on leaves. Margins of spots are characteristically toothed or uneven. As the disease progresses, infected leaves turn yellow and drop. In cool, moist weather circular, raised, brown fruiting bodies, called apothecia, are visible within the spots with the use of a hand lens.

COMMENTS ON THE DISEASE

Common leaf spot is a cool-season foliar disease that requires moisture. The causal fungus overwinters in undecomposed leaves and leaf debris on the soil surface. In spring, spores are forcibly discharged into the air and some land on alfalfa leaves and initiate new infections.

MANAGEMENT

Start looking for leaf spot in spring. Harvest infected alfalfa early because the severity of this disease increases over time. Although the disease does not kill plants, defoliation reduces vigor, hay quality, and yield. In irrigated fields in California, common leaf spot can cause more leaf loss during drying and harvesting than before harvesting. Fungicides are generally not necessary. Some cultivars may be less susceptible than others.

Crop rotation can reduce inoculum in the field. For more information, see CROP ROTATION.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. ***The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.*** *When choosing a pesticide, consider information relating to the pesticide's properties and application timing , honey bees, and environmental impact. Always read the label of the product being used.*			
A. PYRACLOSTROBIN			
(Headline)	6–9 fl oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
B. AZOXYSTROBIN			
(Quadris)	6–15.5 fl oz	4	14
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			

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

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

DOWNY MILDEW (3/17)

Pathogen: *Peronospora trifoliorum*

SYMPTOMS AND SIGNS

The upper surface of leaves infected with downy mildew becomes lighter in color, in some cases almost a mottled yellow. Bluish-gray areas of mycelial mats and spores can be seen with a hand lens on the underside of the affected area. Spores are more often found in the morning when humidity is high. Sometimes entire buds and leaves become infected, resulting in distortion of leaves and general yellowing. Infected leaves drop off the plant, reducing yield and quality.

COMMENTS ON THE DISEASE

Downy mildew is a cool-season foliar disease. It occurs when temperatures are cool and humidity is high enough for the pathogen to infect alfalfa and produce spores. For this reason, it is rarely seen in some years, and even in "wet" years it is usually a problem only for a few to several weeks in spring.

Spring-planted fields are harmed the most because plants are in the seedling stage when weather tends to be most favorable for the disease. Stand survival is usually not affected. In established fields, harvest early to reduce losses.

FUSARIUM WILT (3/17)

Pathogen: *Fusarium oxysporum* f. sp. *medicaginis*

SYMPTOMS AND SIGNS

The first symptom of Fusarium wilt is wilting shoots. Bleaching of the leaf and stem color follows, and finally there may be a reddish tint to the foliage. In roots, dark reddish-brown streaks occur in the stele (the center part of the root that contains the vascular tissue). In advance stages, the entire stele may be discolored. The dark discoloration caused by Fusarium wilt is in contrast to the yellow-brown discoloration of bacterial wilt.

COMMENTS ON THE DISEASE

Fusarium wilt is favored by high soil temperatures. Fusarium wilt was a significant disease in California, but resistant cultivars have now made this disease an infrequent occurrence. For more information on resistant cultivars, see the National Alfalfa & Forage Alliance website.

PHYMATOTRICHOPSIS ROOT ROT (TEXAS ROOT ROT)

(3/17)

Pathogen: *Phymatotrichopsis omnivora* (=*Phymatotrichum omnivorum*)

SYMPTOMS AND SIGNS

The first symptom of phymatotrichopsis root rot on alfalfa is a rot of the outer surfaces of the roots, followed by bronzing of leaves and sudden wilting. Plants die quickly when taproots are girdled. A sheath of soil clings to the roots, and white-to-tan mycelial strands are found on the root surface. The disease appears as somewhat circular spots (fairy rings) within the field, which increase in size following rain or irrigation. The disease develops in late spring as soil temperatures increase.

COMMENTS ON THE DISEASE

Phymatotrichopsis root rot is also called, Texas root rot, phymatotrichum root rot, and cotton root rot. The disease is limited to certain areas in the deserts of Southern California (Palo Verde and to a lesser extent the Imperial and Coachella valleys), Texas and Arizona. The causal fungus has a host range of more than 1800 species of plants.

Extensive research in Arizona and Texas indicates that a *P. omnivora* infestation is most common on alkali calcareous soils in southern humid areas and that the infestation was most likely originally associated with native desert flora.

The fungus survives many years in soil as sclerotia, as deep as 6 feet or more. Sclerotia produce mycelia strands that grow through soil and eventually contact a root. The growth of the fungus is favored by moist soil conditions. The temperature range for growth is 59 to 95°F with an optimum of 82°F. The fungus is more prevalent in heavy alkaline soils than in acidic soils.

Because the causal fungus is almost impossible to eradicate and could affect the value of the land, have the diagnosis confirmed by an expert diagnostician.

MANAGEMENT

Crop rotation with resistant crops such as corn, sorghum, or onion can help prevent the infestation from spreading within a field and reduce the level of inoculum, but it will not eliminate the infestation. For more information, see CROP ROTATION. No resistant cultivars are available.

PHYTOPHTHORA ROOT AND CROWN ROT (3/17)

Pathogen: *Phytophthora megasperma*

SYMPTOMS AND SIGNS

The above ground symptom of Phytophthora root and crown rot is plant wilting, typically occurring quite suddenly and often followed by plant death. The belowground symptom is tan-to-brown lesions on taproots, especially where a lateral root emerges. Lesions eventually turn black while the center of the root becomes yellow. In the root interior, orange-to-reddish streaks spread up several inches from the rotted end of the roots. Lesions can appear at any depth where water drainage is impeded. Occasionally, the disease may spread to the crown from the taproot.

COMMENTS ON THE DISEASE

Phytophthora root rot is a cool-season crown and root disease, most often occurring in the San Joaquin Valley from March through May. It is important where soil water is excessive and can affect large areas of a field. Root and crown rot is common at the tail end of flood-irrigated fields where water collects.

The causal organism survives in soil as mycelia in infected plant tissue or as thick-walled oospores. The fungus also produces thin-walled sporangia that release motile zoospores in the presence of free water.

If the crown becomes infected, the plant will likely die. If infection is limited, the plant may continue growing at a reduced rate, and it will be susceptible to other pests and diseases. In these survivors, the taproot is usually killed and lateral roots develop to compensate. However, lateral roots will never grow as vertically or as deep as a taproot, resulting in plants only being able to take up water from a limited depth. Root and crown rot can be injurious to seedling stands, but is more common in established fields.

MANAGEMENT

Proper water management, use of resistant cultivars, and crop rotation are key to keeping Phytophthora root rot under control in alfalfa production. Take the following steps to decrease the amount of time that soil is saturated with water:

- Till deeply to reduce compaction
- Reduce the length of flood irrigation runs
- Shorten irrigation time
- Level land before planting
- Install a tailwater ditch to remove excess water
- Plant on beds to help alleviate disease severity

Be careful when using return water because this and other pathogens (and nematodes) can be carried in recirculated irrigation water. Cultivars resistant to Phytophthora root rot are listed in the National Alfalfa & Forage Alliance website. Use resistant cultivars with sound cultural practices in fields known to have problems with *Phytophthora*.

RHIZOCTONIA ROOT CANKER (3/17)

Pathogen: *Rhizoctonia solani*

SYMPTOMS AND SIGNS

Tan, elliptical lesions on the taproot in the areas where lateral roots emerge are distinctive symptoms of *Rhizoctonia*-related diseases. In winter when the fungus is inactive, these sunken lesions will turn black and appear to be inactive. If roots are girdled during summer, the plant will die. If infection is not severe, new roots will emerge when temperatures are too cool for the fungus.

COMMENTS ON THE DISEASE

Rhizoctonia root canker, also known as crown and stem rot, occurs during periods of high temperatures and high soil moisture. The fungus occurs worldwide and also causes serious seedling damping-off; however in California, most new stands are planted when temperatures are less than ideal for disease development. The disease is mainly found in the low desert valleys of Palo Verde, Imperial, and Coachella. Only certain strains of the fungus can cause the root canker form of disease. No control measures are known for these diseases.

SCALD (FLOODING AND HIGH TEMPERATURE INJURY)

(3/17)

Pathogen: none (abiotic disorder)

SYMPTOMS AND SIGNS

Symptoms of scald include an off-color of the foliage and wilting, even though the soil is wet. Roots may rot and have a putrid odor when removed from the soil. The water-conducting tissue of affected roots die and becomes brown.

Scald is often confused with Phytophthora root rot because both occur in saturated soil conditions, but if temperatures have not exceeded 100°F, it is probably not scald.

COMMENTS ON THE DISEASE

Scald is related to the combination of high soil temperatures and length of time soil is saturated with water. When air temperatures are in the range of 104 to 113°F, alfalfa is extremely susceptible to flooding injury. Scald is usually limited to hot desert valleys, such as the Imperial and Palo Verde valleys, when soil is saturated for long periods after irrigation or rainfall. Affected plants may die within 3 or 4 days after irrigation.

Fields that have been recently mowed are much more susceptible to scald than fields closer to harvest.

MANAGEMENT

The primary control measure is proper water management.

- Irrigate at night, when temperatures are cooler, or during the day for relatively short periods (e.g., 4 hours) when temperatures are high to reduce the likelihood of scald. Some soils,

however, remain saturated long after irrigation because of heavy texture, slope of the land, and length of the irrigation run. Avoid irrigation when temperatures are over 109°F**.** Drain excess irrigation water from fields as soon as possible to avoid water ponding during periods of high daytime temperatures.

- Do not irrigate newly-mowed plants until enough regrowth occurs to prevent submersion of entire plants.

SCLEROTINIA STEM AND CROWN ROT (WHITE MOLD)

(3/17)

Pathogen: *Sclerotinia trifoliorum, Sclerotinia sclerotiorum*

SYMPTOMS AND SIGNS

There are two species of *Sclerotinia* that cause stem and crown rot, both causing the same symptoms and requiring similar environmental conditions for infection. *Sclerotinia sclerotiorum* has a wider host range than *S. trifoliorum,* which mostly infects legumes. When the disease is active it is easily identified by white, cottony, mycelial growth on crowns or stems. In seedling fields infected plants wilt and die, often causing stand loss. For established fields, infected stems wilt and die. The disease can grow into crowns, but plants usually recover.

The first obvious symptom of disease is wilting stems. If conditions are humid or moist, white mycelium can be found growing on the stems and sometimes on the soil adjacent to infected plants. Diagnosis can be confirmed by the presence of black, hard resistant structures (called sclerotia) that look like peppercorns. They can be round or irregular in shape and, when broken open, have a white interior. Sclerotia are found at the base of stems, on soil near the crown, or inside infected stems. Dead stems are hollow and easily flattened between the thumb and fingers, making it easy to feel sclerotia, if present, inside. Sclerotia found in stems are elongated in shape.

COMMENTS ON THE DISEASE

Sclerotinia stem and crown rot is a cool-season disease. In wet or foggy winters, this disease can be serious on stands planted in September and October, especially when rapidly growing plants form a dense canopy in which high humidity is favorable for disease. Weeds, such as chickweed, further encourage disease by prolonging moist conditions in the canopy.

All the stems of a plant may be infected and die, which makes the plant appear to be dead. But crowns may still be alive and healthy regrowth can appear later in spring, especially in established plants. If plants are young, weakened by stress or other factors, or if favorable conditions for disease exist long enough, entire plants may be killed.

MANAGEMENT

The best strategy for established fields is to remove as much foliage before winter as possible by mowing or grazing. When removing an alfalfa stand, deep plowing will prevent germination of most sclerotia in following years; however, neighboring fields of alfalfa or weed hosts (e.g.,pineappleweed, sowthistle, groundsel, mayweed, mustards, radish, and legumes) can be the source of new infections. Good weed control reduces potential hosts. It also opens the canopy, allowing air movement and sunshine at the base of plants, thereby reducing humidity and moisture required by the fungus to start and maintain infections. In dry winters, this disease is not a problem. There is no effective genetic-based resistance incorporated into commercial varieties at this time.

Early February plantings usually escape disease, because environmental conditions that favor disease do not usually last for extended time periods. Growers who prefer to plant in September and October face potential damage from this disease during the first winter. The disease may thin stands and, on rare occasions, replanting may be necessary.

Research has not shown conclusively that using herbicides to burn back seedling growth is effective in reducing disease. The fungicide premix, pyraclostrobin/boscalid (Pristine), can reduce disease severity and increase yield in the first cutting, but timing of application is challenging. Apply just before or after infection. If fog develops after substantial rain, ground application may be difficult. Application in advance of rain and fog may not be useful if the forecast was incorrect and if dry windy conditions, which do not favor disease development, occur following a storm.

The mixture of two active ingredients with different modes of action (pyraclostrobin and boscalid) is more expensive but provides better disease control and should slow the development of resistant *Sclerotinia* strains than using a strobilurin (pyraclostrobin or azoxystrobin) by itself.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. ***The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table.*** *When choosing a pesticide, consider information relating to the pesticide's properties and application timing , honey bees, and environmental impact. Always read the label of the product being used.*			
A. PYRACLOSTROBIN/BOSCALID			
(Pristine)	14–18 oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11) and carboxamide (7)			
B. PYRACLOSTROBIN			
(Headline)	6–9 fl oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
C. AZOXYSTROBIN			
(Quadris)	6–15.5 fl oz	4	14
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			

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

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

SEEDLING OR DAMPING-OFF DISEASES (3/17)

Pathogen: *Pythium ultimum*, *P. irregulare*, *P. violae*, *Rhizoctonia solani, Phytophthora megasperma*

SYMPTOMS AND SIGNS

Damping off is a name given to a condition where seeds are killed before germination or seedlings are stunted or collapse and die shortly after emergence. Seeds destroyed before germination are discolored and soft. After seed germination, symptoms include brown necrotic lesions along any point of the seedling. Lesions that girdle the young root or stem lead to plant death. Partially girdled plants, as well as those subject to continued root tip necrosis, may be stunted and yellowish in color to varying degrees.

A discolored, constricted area near the soil surface may be seen in older seedlings. The magnitude of the dark discoloration is dependent upon the age of the seedling as well as the duration of environmental conditions favorable for disease development.

Pythium ultimum and *P. irregulare* cause both pre- and postemergence damping-off of alfalfa in California. When emerged seedlings are killed, the stem has a water-soaked appearance and no definitive demarcation between healthy and diseased tissue. *Pythium violae* causes root -tip necrosis and inhibition of lateral root formation. *Rhizoctonia solani* may cause preemergent death of seedlings but usually causes postemergent necrosis of the stem at or near the soil surface. Necrosis is marked by a distinct margin between infected and healthy tissue.

Phytophthora megasperma, another common soilborne pathogen, can be particularly devastating in poorly drained soils. See PHYTOPHTHORA ROOT ROT for more information.

COMMENTS ON THE DISEASES

Pythium and *Rhizoctonia* are common in most soils where they persist indefinitely. Both fungi are transported by water, contaminated soil on equipment, and movement of infected plant materials. Both have wide host ranges. Damping-off is favored by poor growth of alfalfa seedlings resulting from such factors as unfavorable temperatures, excessive moisture, low light, or improper fertilization.

Damping-off caused by *Pythium* spp. usually occurs under cool soil temperatures in fields with poor drainage.

Damage by *R. solani* is often related to the amount of organic matter that remains in the soil from the previous crop, with damage increasing as the level of organic matter increases.

MANAGEMENT

Planting high-quality seed under environmental conditions favoring rapid germination and seedling growth reduces the chance of infection.

- Avoid planting in November and December.
- Avoid excessive irrigation and compacted or poorly-drained soils.
- Purchase seed treated with an appropriate fungicide to protect seedlings from the damping-off pathogens.

Although crop rotations do not eliminate these pathogens because of their wide host ranges and longevity in the soil, rotations with crops like small grains may help reduce inoculum levels.

SPRING BLACK STEM (3/17)

Pathogen: *Phoma medicaginis*

SYMPTOMS AND SIGNS

Spring black stem is a cool-season foliar disease. Symptoms include small, black-to-dark brown spots on lower leaves, petioles, and stems. The lesions are irregularly to triangularly shaped. As they increase in size, lesions coalesce and become light brown. Affected leaves turn yellow and often wither before falling. Lesions on stems and petioles enlarge, causing large areas near the base of the plant to turn black. Young shoots are often girdled and killed. Most damage occurs before the first cutting.

COMMENTS ON THE DISEASE

The causal fungus produces brown-to-black fruiting bodies (pycnidia) on overwintered stem and leaf lesions. In early spring, spores released from pycnidia on dead stems during wet weather or overhead irrigation are splashed onto foliage and stems. In addition new shoots are infected as they grow through the crop residue or stubble. The fungus also may be seedborne.

MANAGEMENT

Control measures include early cutting to reduce leaf loss, planting resistant cultivars, and planting pathogen-free seed. Crop rotation can reduce inoculum in the field. For more information, see CROP ROTATION.

STAGONOSPORA CROWN AND ROOT ROT (3/17)

Pathogen: *Stagonospora meliloti*

SYMPTOMS AND SIGNS

Symptoms of Stagonospora crown and root rot include rough and cracked bark tissue on infected roots and crowns. The presence of red flecks in diseased root tissue is a distinctive diagnostic symptom. Fine red streaks also occur in the xylem (water-conducting tissue) in the center of the root, below rotted portions of the crown. Affected crown tissue is generally firm and dry, unless secondary organisms invade the tissue. The pathogen also may infect leaves and stems, causing irregular, bleached lesions with diffuse margins. Infected leaves soon drop after lesions form.

COMMENTS ON THE DISEASE

Stagonospora crown and root rot is a cool-season crown and root rot disease. Spores of the pathogen form in black pycnidia and are spread by water that splashes them from infected leaves, stems, or plant debris onto susceptible tissue. The fungus enters the crown through stems and grows slowly downward into the taproot. Although the infection can take 6 months to 2 years to kill a plant and aboveground symptoms may be indistinct, the disease reduces plant vigor and yield. Leaves and stems are generally

infected during spring rains, but crown infections can occur anytime. The disease is most damaging when alfalfa is not actively growing.

MANAGEMENT

To minimize the effects of Stagonospora crown and root rot, provide optimum growing conditions for the alfalfa crop. Consider rotating out of alfalfa for 2 years to eliminate the sources of inoculum within a field. For more information, see CROP ROTATION. No resistant cultivars are available, but germplasm with moderate resistance has been released.

STEMPHYLIUM LEAF SPOT (3/17)

Pathogen: *Stemphylium botryosum*

SYMPTOMS AND SIGNS

A tan center and a dark border around an irregularly shaped lesion distinguish Stemphylium leaf spot from other leafspot diseases. Once the border is formed, the spot ceases to get larger in size. New spores will form in the center of the leaf spot.

COMMENTS ON THE DISEASE

Stemphylium leaf spot is a cool-season foliar disease. Cool temperatures (60–70°F) and moist weather favor infection and spread. The disease is usually found in first and second cuttings. Because defoliation occurs only under heavy disease pressure, Stemphylium leaf spot is not considered as serious as some other leaf spot diseases.

MANAGEMENT

No known control measures are used. Early harvest is an option with severe infestations. Some varieties may have more levels of resistance than others, but companies do not commonly report resistance to this disease.

SUMMER BLACK STEM AND LEAF SPOT (3/17)

Pathogen: *Cercospora medicaginis*

SYMPTOMS AND SIGNS

Symptoms of summer black stem and leaf spot usually appear after the alfalfa has grown a dense canopy. Defoliation from the base of the stem to the top is the most obvious symptom, but leaf spots usually appear first. Leaf spots begin as brown areas with a wavy margin. As spores on the surface of the spot are produced, the color of the spot appears gray or silvery. A diffuse yellow margin often surrounds the spot. Brown lesions also form on stems. Disease development is favored by high humidity (close to 100%) and temperatures ranging from 75 to 82°F.

COMMENTS ON THE DISEASE

Summer black stem is a disease of limited importance and has been observed primarily in the Imperial Valley.

MANAGEMENT

Harvest early before extensive defoliation occurs to minimize losses.

VERTICILLIUM WILT (3/17)

Pathogen: *Verticillium albo-atrum*

SYMPTOMS AND SIGNS

Verticillium wilt symptoms include yellowing of leaf tips, sometimes in a V-shaped pattern. The edges of some apical leaflets will roll upward. As symptoms progress, leaves become desiccated and sometimes reddish in color. They may defoliate, leaving behind a stiff petiole. The infected stem does not wilt and remains green until all the leaves are dead. Xylem tissue in roots becomes brown in color.

COMMENTS ON THE DISEASE

Verticillium wilt of alfalfa is a warm-season disease and can be serious in susceptible varieties. Yields have been reduced by 50% in the second year of production. This disease has been found in alfalfa growing areas in the Mojave Desert and Riverside and San Bernardino counties. It has not yet been identified in the Central Valley or Imperial, Palo Verde, or Coachella valleys but has been found in a few coastal areas.

Verticillium albo-atrum can be carried internally and externally on alfalfa seed. The fungus also survives in alfalfa hay and in animal manure. The fungus penetrates alfalfa roots directly or through wounds. Spread within an alfalfa field can also occur through infection of cut stems when swathing. The fungus has been detected on sheep, which are trucked from one region to another to graze fields in winter months.

MANAGEMENT

The most practical control measure is to plant resistant varieties. Cultivars resistant to *Verticillium* are listed on the National Alfalfa & Forage Alliance website.

In areas where the disease does not occur, take care to prevent importation of infected seed or plant materials:

- Clean or power wash harvesting equipment when moving from infested fields into new plantings.
- Cut infested fields last in the harvest cycle to avoid spreading the pathogen from field to field.
- Be careful when using return water from infested fields because pathogen spores can be carried in recirculated irrigation water.

Nematodes

(Section reviewed 1/17)

Scientific Names:

Stem nematode:
- Alfalfa stem nematode: *Ditylenchus dipsaci*

Root-knot nematodes:
- Northern root-knot nematode: *Meloidogyne hapla*,
- Southern or Cotton root-knot nematode): *Meloidogyne incognita*
- Javanese root-knot nematode: *Meloidogyne javanica*
- Thames root-knot nematode: *Meloidogyne thamesi*
- Peanut root-knot nematode: *Meloidogyne arenaria*
- Columbia root-knot nematode: *Meloidogyne chitwoodi*

Lesion nematodes:
- Cobb's meadow nematode: *Pratylenchus penetrans*
- California meadow nematode: *Pratylenchus neglectus*

DESCRIPTION OF THE PESTS

Plant-parasitic nematodes are microscopic thread-like worms that live in soil and plant tissues and feed on plants by puncturing and sucking the cell contents with a needlelike mouthpart called a stylet. The alfalfa stem nematode feeds in the stems and crowns of the alfalfa plant, while the other nematodes listed above feed on roots.

The nematode life cycle typically includes an egg stage, four larval stages, and an adult stage. The life cycle, from egg hatching to egg production, usually requires 3 to 6 weeks under optimal conditions to complete. Environmental factors, such as soil temperature, soil moisture, host status, and time of infection, can influence the number of nematode generations completed within a year. Nematodes move relatively short distances on their own (a few inches per year), but they are easily spread long distances by soil movement (wind, farm equipment, etc.), irrigation water, nursery stock, seed, and debris in seed and hay.

DAMAGE

Both stem nematode and root-knot nematodes cause substantial damage and are of major concern in California. In general, the symptoms and damage described below are characteristic of nematode problems but not diagnostic because they could result from other causes as well. Nematode injury typically occurs in areas or pockets of the field and is not evenly distributed throughout the field.

Alfalfa Stem Nematode

Stem nematodes enter bud tissue and migrate into developing buds. Infected stems become enlarged and discolored, nodes swell, and internodes become shorter than those on healthy plants. Alfalfa plants infected with the alfalfa stem nematode have stunted growth, fewer shoots, and deformed buds. Another typical sign of a stem nematode infection is the presence of "white flags,", which are individual alfalfa stems and leaves that turn white, especially during spring months (typically after the first cutting). White flags are caused when nematodes move to leaf tissue and destroy chloroplasts, leaving pale leaf tissue. Stem nematode feeding may also injure the alfalfa crowns, creating entry wounds for fungal and bacterial pathogens (such as *Phytophthora* or *Fusarium*) that can cause crown rot and reduced yields. As alfalfa plant dieback occurs, weeds often invade the open areas. Stem nematodes are most prevalent

during late winter (January–March) when cooler temperatures favor their development (optimum 59-68°F).
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Root-Knot Nematodes
Alfalfa infection caused by *Meloidogyne* species may be confined to localized areas of a field or extend throughout an entire field. The extent of the damage in the field depends on several factors, including initial nematode numbers, alfalfa variety, and soil temperature at planting time. High initial numbers and relatively warm soil temperatures may cause serious injury to seedlings, resulting in stunting.
Root knot nematode (*Meloidognye spp.*) infects and parasitizes roots of alfalfa plants and causes the plant cells to enlarge into small oval galls on the roots that can be seen with the naked eye. Galls caused by root-knot nematodes are accompanied by lateral root growth, unlike galls caused by the beneficial nitrogen-fixing bacteria, which are easily rubbed off the root with your thumb. In a heavily infested field, young seedlings may be killed by this nematode, even though roots may not display galls.

The Columbia root-knot nematode (*M. chitwoodi*) produces symptoms similar to other root-knot nematodes, but it is less pathogenic to alfalfa. This nematode causes tiny galls that can easily be missed if roots are not examined carefully.

Root-knot nematodes, like stem nematodes, may enhance the development of diseases such as bacterial wilt, Phytophthora root rot, and Fusarium wilt. In addition, damage by the alfalfa stem nematode may be more severe when root-knot nematodes are also present.

Root Lesion Nematodes
Of the two species of root lesion nematode listed, *P. penetrans* is more pathogenic. However, it only occurs in localized areas of the state.

Plants infected with root lesion nematodes exhibit aboveground symptoms such as stunting and nutrient deficiencies. Impact on the root system includes reduced root growth and black or brown lesions on the root surface. Lesions may fuse to cause the entire roots to appear brown. Secondary infections of roots by bacterial and fungal pathogens commonly occur with a root lesion nematode infestation; feeding by root lesion nematodes may overcome the resistance of the alfalfa varieties to these pathogens. Damage caused by lesion nematode depends on the alfalfa variety and the species of lesion nematode present in the field. Under severe infestation, young plants often die, resulting in yield reductions.

FIELD EVALUATION

It is critical to know the nematode species present and the density of their populations to make management decisions. If a previous field or crop had problems caused by nematodes that are listed as pests of alfalfa, numbers may be high enough to cause damage to seedlings. If nematode species have not previously been identified, take soil samples and send them to a diagnostic laboratory for identification.

How to Sample Nematodes in the Soil

1. Divide the field into sampling blocks of not more than twenty acres each that represent cropping history, crop injury, or soil texture.
2. Take several subsamples randomly from a block, mix them thoroughly and make a composite sample of about 1 quart (1 liter) for each block. If root-feeding nematodes are suspected, take soil samples from within the root zone (6 to 18 inches deep).

3. Place the samples in separate plastic bags, seal them, and place a label on the outside with your name, address, location, the current and previous crop, and the crop you intend to grow.
4. Keep samples cool (do not freeze), and transport as soon as possible to a diagnostic laboratory.

How to Sample for Stem Nematode

Stem nematode is easily identifiable under a dissecting scope. If symptoms of stem nematode are evident, such as stunted growth and open patches in the field

1. Cut several stems with symptoms from several different plants.
2. Cut stems into half-inch pieces into a petri dish using scissors or a razor blade.
3. Add water until the stem pieces are submerged.
4. Let the sample sit for 15 minutes.
5. Look for large, clear worms that appear to be swimming.

Contact your farm advisor for more details about sampling, to help you find a laboratory for extracting and identifying nematodes, and for help in interpreting sample results.

MANAGEMENT OF NEMATODES IN ALFALFA

Once the species of nematodes has been identified from the field, management strategies need to be tailored to the species that are present. Because resistant alfalfa varieties are resistant to specific species and not to all pest nematodes of alfalfa, accurate identification is important.

ALFALFA STEM NEMATODES

Resistant Varieties

Use of highly resistant stem nematode alfalfa varieties is recommended for production areas where stem nematodes are problematic, to help prevent yield and stand losses. Development of alfalfa varieties with >70% resistance to stem nematodes is ongoing (current levels are mostly >50%). For more information on current nematode-resistant varieties, see the list of alfalfa varieties provided by the National Alfalfa & Forage Alliance. website, available online at http://alfalfa.org.

Prevention (Sanitation and Exclusion)

- Use certified clean, nematode-free seed. Stem nematode is not seedborne, but can live on alfalfa chaff. Certified seed is well cleaned to remove alfalfa debris and stem nematodes and then tested for the presence of stem nematode before seed sales.
- Avoid moving contaminated farm machinery or livestock from an infested field to a clean field.
- Avoid using contaminated wastewater or tail water.
- Manure from feedlots where cattle have been fed infected hay needs to be composted before use and kept out of clean fields.
- Clean equipment when moving from a stem nematode infested field to a clean field. This can be done using a high-pressure washer or blower, or by cutting grass hay prior to moving back into alfalfa.

Cultural Practices

Fall burning (in alfalfa seed-production systems) decreases nematode infection and plant mortality, while spring burning appears to enhance infection and increase plant mortality.

The alfalfa stem nematode has a very limited host range including alfalfa and, to a lesser extent, sainfoin and potatoes. Consequently, rotation with nonhost crops such as tomatoes, small grains, beans, and corn

on a 2- to 4-year basis should reduce alfalfa stem nematode numbers (longer is better for heavily infested fields). Control volunteer alfalfa plants in subsequent crop rotations. Note: Overseeding older alfalfa stands with grasses is not a rotation, since alfalfa hosts remain in the field.

Chemical Control

No nematicides are registered for use against the alfalfa stem nematode. Fumigation before planting may be too costly relative to potential economic benefits.

ROOT-KNOT NEMATODES

Resistant Varieties

The use of resistant alfalfa varieties is probably the most practical means of managing root-knot nematodes. There are a number of different commercially available alfalfa varieties that are with resistance to the northern and southern root-knot nematodes. Unlike other crops such as tomatoes, planting resistant varieties of alfalfa does not help reduce nematode numbers because there will always be some alfalfa plants in the field that have no resistance to root-knot nematodes, based on alfalfa resistant ratings.

Crop Rotation

Depending on the root-knot nematode species present in the field, crop rotation can be a useful management strategy. It is important to have the species correctly identified. For *Meloidogyne incognita,* the following are good rotation crops: barley, oats, wheat, cole crops, corn, cotton, hops, sudangrass, cowpea, and watermelon. For *M. hapla,* cotton serves as a good rotation crop.

Chemical Control

Soil fumigation before planting can be effective against the northern root-knot nematode, but fumigants are expensive and generally not economically feasible on alfalfa. No nonfumigant nematicides are currently registered on alfalfa.

ROOT LESION NEMATODES

Resistant Varieties

Screening is ongoing to identify alfalfa varieties with resistance to lesion nematodes, but currently there are no commercially certified varieties with lesion nematode resistance.

Crop Rotation

Lesion nematodes have a very wide host range, and more than one species may occur in a field, making crop rotation ineffective for lesion nematode management. Leaving a field fallow and weed free, can reduce lesion nematode numbers, but not enough to prevent crop damage to new alfalfa plantings. Nematicides are not cost effective for alfalfa production. If lesion nematodes are present in the field, it is important to maintain good plant health. Plants that are stressed (for example from too little water) will be more susceptible to lesion nematode damage.

For more information on parasitic nematodes in alfalfa, see Irrigated Alfalfa Management available at http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/.

Weeds

General Information for Weeds

(Section reviewed 3/17)

HERBICIDE-TOLERANT VARIETIES AS A WEED MANAGEMENT STRATEGY (3/17)

Glyphosate-tolerant alfalfa (Roundup Ready alfalfa) is genetically engineered to tolerate over-the-top applications of glyphosate. Roundup Ready alfalfa allows growers a weed management option for many difficult-to-control weeds. Glyphosate controls most winter and summer annual weeds associated with alfalfa and suppresses or controls some problematic perennial weeds such as bermudagrass, nutsedge, quackgrass, and dandelion that are not currently well controlled with conventional herbicide systems.

While glyphosate controls a broader weed spectrum than the conventional herbicides used on alfalfa, it does not have residual control. Therefore, it is important to either tank-mix glyphosate with a soil residual herbicide or spray glyphosate after weeds have germinated and the alfalfa is large enough to suppress further weed germination. On the other hand, do not delay glyphosate applications so long that weeds become large and difficult to control.

Generally, the best time to spray seedling alfalfa is when the alfalfa is between the three- and six-trifoliolate leaf stage. With later applications, weeds may be too large for adequate control and alfalfa vigor may already be affected. Sometimes it may be necessary to make two applications of glyphosate during alfalfa stand establishment if a soil residual herbicide is not used.

Glyphosate can also be used for winter weed control and between cuttings to control summer annual grasses, such as yellow and green foxtail (*Setaria* spp.) and barnyardgrass (*Echinochloa crus-galli*). The number of applications depends on the geographic area and the infestation level. The overuse of glyphosate can lead to shifts of tolerant weeds with poor control and or glyphosate-resistant weeds developing.

For more information on glyphosate resistance, see Herbicide resistance: Glyphosate (available online at http://ipm.ucanr.edu/IPMPROJECT/glyphosateresistance.html).

PREVENTING WEED RESISTANCE AND WEED SHIFTS (3/17)

The potential for weeds to develop resistance to specific herbicides is always a concern when herbicides are used, but with Roundup Ready alfalfa, weed resistance is of greater concern because of the tendency to use a single herbicide repeatedly for several years.

Glyphosate is an herbicide that controls many weeds, including hard-to-control species. Because many growers may choose to use low-cost herbicide programs such as glyphosate alone, a real potential exists for the evolution of glyphosate-tolerant weeds. Researchers in California have already identified and confirmed glyphosate-resistant ryegrass *(Lolium rigidum)*, horseweed and hairy fleabane (*Conyza* spp.), and junglerice (*Echinochloa colona*). Other weeds are becoming more difficult to control in other Roundup Ready cropping systems.

A weed shift is another potential outcome of relying on a single herbicide or control strategy to manage weeds. A weed shift occurs when populations of tolerant weed species increase. While glyphosate controls most weeds, there are some tolerant species including cheeseweed (*Malva parviflora*), burning nettle (*Urtica urens*), filaree (*Erodium* spp.), and purslane (*Portulaca oleracea*). The prevalence of these weeds and others may increase if glyphosate alone is used repeatedly.

Avoid continuous Roundup Ready crops (e.g., Roundup Ready corn, sugarbeets, or cotton), since the continuous use of glyphosate is likely to result in weed shifts or resistant weeds. For more information on transgenic alfalfa, see HERBICIDE-TOLERANT VARIETIES AS A WEED MANAGEMENT STRATEGY.

No matter which type of production system is used (standard or Roundup Ready), a well-balanced, long-term weed management approach is important. Such a program will incorporate resistance management strategies, including crop rotation, rotation of herbicides that have different mode-of-action group numbers, herbicide tank mixes with complimentary modes of action, and control of escaped weeds by tillage or hand removal in order to delay or prevent the occurrence of resistant weeds or significant weed shifts.

Tank mixing glyphosate with a soil-active herbicide is often an effective practice to reduce the likelihood of herbicide resistance or weed shifts and to improve weed control. It is important to avoid rotation with other Roundup Ready crops whenever possible (such as Roundup Ready cotton, corn, or sugarbeets), to avoid the potential for overuse of glyphosate and possible problems with glyphosate-tolerant volunteer crops.

Take the following factors into consideration when making a decision whether or not to use Roundup Ready varieties:

- What are the dominant weed species present (annual versus perennial) and how are they controlled with conventional herbicides versus glyphosate?
- What is the density and extent of the perennial weed infestation?
- Is the price of the seed with the technology fee cost effective?
- Are your buyers willing to accept transgenic alfalfa?

For more information on the management of weed shifts and resistance, see *Avoiding Weed Shifts and Weed Resistance in Roundup Ready Alfalfa Systems,* UC ANR Publication 8362.

Weeds

Management in Seedling Alfalfa

(Section reviewed 3/17)

INTEGRATED WEED MANAGEMENT IN SEEDLING ALFALFA (4/24)

Uncontrolled weeds in seedling alfalfa can cause loss of the stand during crop establishment. Weed infestations can weaken young alfalfa plants, retard growth, delay the first cutting, reduce quality, and result in long term damage to crop yield and stand persistence.

Proper establishment and management of an alfalfa stand are essential for weed control. It is not cost-effective to control weeds in a thin or weak stand. Plant alfalfa at the right time (early fall) and depth; alfalfa that germinates and grows rapidly in response to warm temperatures, adequate soil moisture, and shallow planting (0.25 inch) will usually develop into a competitive stand with reduced weed problems throughout the stand life. Adequate soil preparation and soil fertility, especially phosphorus, is also essential in establishing and maintaining a vigorous stand. Plant only alfalfa varieties that are well adapted to your climate and soil type.

For soils with a high salt content or areas where soils lack adequate drainage, such as heavy clay soils, plant alfalfa using broadcast or drilled methods on raised beds or with shallow corrugations which allow water to drain off the field. Possible weed problems associated with this practice include increased weed numbers in the furrows and decreased effectiveness of water-run herbicides, caused by uneven water distribution across the bed. When planted on beds, alfalfa is not as competitive against weeds, because the furrow is not covered completely by the crop canopy.

MONITORING

Start looking for weeds when moisture conditions favor germination and as the crop emerges. Correctly identifying weeds is fundamental to planning a weed control program. It is important to know the kind and abundance of weeds present in an alfalfa field. Weeds are easiest to identify when full grown and flowering; seedling weeds can be more difficult to identify. However, weed control decisions must be made early, on the basis of identifying weed seedlings. For help in identifying weed seedlings, view photos of common winter annual, summer annual, and perennial weed seedlings available in the online version of this guideline. Properly identify weeds; misidentification could reduce or eliminate the efficacy of weed control practices.

Monitor for weeds when they are expected to emerge.

- Monitor weeds in the field well ahead of planting to develop a weed management strategy; preirrigate if necessary.
- In the Central Valley most winter annual weeds start to germinate in October and continue to germinate until late February whenever soil moisture and temperature conditions are favorable. Summer annual weeds, especially grasses, start to germinate in late February and can continue to germinate until midsummer following each irrigation event.
- In the intermountain area, winter annual weeds typically emerge in late September or October with the first fall rains, may cease in mid-winter depending on the serverity of the cold and continue to

germinate into March or early April. Summer annual weeds start to germinate in April or May and continue through midsummer whenever soil moisture is adequate.

- In the Low Desert, weeds can germinate throughout the year as long as there is enough moisture in the soil (germination occurs after each irrigation). Generally, summer annual weeds emerge from March through October with the highest numbers seen around June. Winter annual weeds germinate from November through mid-February.
- Record observations on a monitoring form *(available online)*.

The need for herbicide depends on weed numbers and species, their competitiveness and toxicity to livestock, and the potential market for the alfalfa. Vigor of the alfalfa stand is a complicating factor; weakened stands will require an herbicide application, whereas vigorously growing denser ones may not.

WEED MANAGEMENT BEFORE PLANTING

Prepare fields so drainage is adequate to prevent ponding or uneven irrigation. Avoid planting in fields that have serious perennial weed infestations. One option is to preirrigate and then apply an appropriate herbicide or cultivate emerged weeds before planting.

Time of Seeding

It is important to select planting time carefully; generally, fall (September–October) is the preferred time in the San Joaquin and Sacramento valleys with February and March being the next best window. Late August is the preferred time in the intermountain area for a fall planting and April to mid-May for spring seeding. Fields planted in spring can be seriously infested by summer annual weeds. Alfalfa seed planted too late (November–December) will germinate and grow slowly, allowing winter weeds that grow faster to become established before alfalfa reaches a size that can be safely sprayed with an herbicide.

If a spring seeding is planned, a planting date of February through March in the Central Valley can reduce problems with winter annual weeds. However, planting too late in spring can require irrigation, causing summer grasses to become an issue. Planting after November usually results in lower yields than planting in September through October.

If fields infested with field bindweed, perennial grasses, or nutsedge must be used, plant in early fall while these weeds are dormant and less competitive, or consider planting Roundup Ready alfalfa and manage with glyphosate. This will ensure that alfalfa is established and vigorous when these perennials start regrowing again in spring.

Depth of Planting

Depending on the soil type and texture, plant seeds shallowly into a firm seedbed (no deeper than 0.5 inch) to provide both proper soil-seed contact and encourage timely alfalfa seed germination. Seeds placed too shallowly may dry out and die, or they may develop poor roots. Seeds planted too deeply may be unable to reach the surface to emerge after germination or may have reduced vigor.

Seeding Rate

One of the few tools for weed management in organic production is the use of higher rates of seeding for competitiveness against weeds. Plant between 15 to 25 pounds of seed per acre, or slightly higher when seedbed conditions are sub-optimal. The goal is 25 to 70 emerged plants per square foot. However, seeding methods (depth, soil-seed contact, and soil preparation) are more important factors affecting

stand vigor and success than seeding rate; high seeding rates cannot make up for suboptimum soil preparation or poor seeding methods.

Interplanting Oats in Seedling Alfalfa

Planting a low density of oats with alfalfa can suppress weeds without the use of herbicides and reduce erosion during stand establishment. It is especially appropriate for organic production systems. The first cutting will have lower alfalfa content but, in combination with the harvested oats, will provide higher yields of forage than pure alfalfa stands. The next two cuttings are usually only slightly affected and there is no effect on later cuttings or stand life, provided the oat seeding rate is not too high (i.e., above 20 lb/acre).

Planting oats with alfalfa is often a two-step process because of the difference in seed sizes. Establish the stand at the normal alfalfa planting time. If possible, preirrigate and cultivate to eliminate weeds before planting. Oat seed is planted first. The ideal seeding rate for oat in California is 8 to 16 pounds per acre with the standard alfalfa seeding rate. Most standard grain drills cannot plant oats at this low rate, so broadcast and incorporate oats with a disc or springtooth harrow. Do not apply nitrogen; it may make the oats too competitive.

A short, midseason oat variety works best with an early fall planting because it matures with the alfalfa and is less likely to lodge and reduce alfalfa growth. In spring plantings, an early maturing variety produces more growth by the time alfalfa is ready to cut.

The first cutting may be mostly oats. Curing time for the first cutting may be several days longer than that for pure alfalfa. For additional information on interplanting oats in alfalfa, see *Overseeding and Companion Cropping in Alfalfa,* UC ANR Publication 21594.

Herbicides

(View photos online of weeds not controlled by herbicides in conventional alfalfa.)

If a field has a history of weeds, an application of a preplant herbicide may be an option, but most weed control programs currently focus on postemergence herbicides instead. This approach allows better assessment of the weed numbers and species to select the appropriate herbicide or herbicide combination for the weeds that are present. To control most emerged annual and perennial weeds, a postemergence herbicide can be applied either before planting or before crop emergence, depending on the particular herbicide being used. If postemergence herbicides are to be used before planting, preirrigate to germinate the weed seeds.

If a preplant incorporated herbicide is preferred, such as EPTC (Eptam), it should be applied to the soil surface and mechanically mixed into the soil before planting the alfalfa seed. If a disc or a ground-driven tiller is used to incorporate herbicides, work the soil to double the desired depth of incorporation; power tillers incorporate to the set depth. To be effective, preplant herbicides require soil moisture.

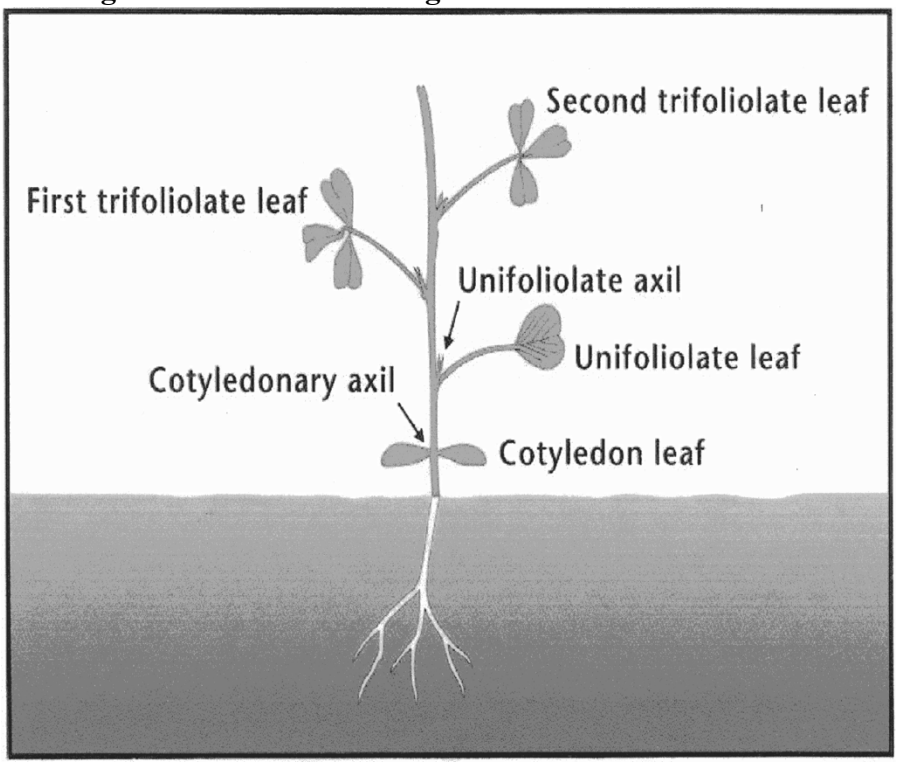
The use of Roundup Ready alfalfa allows glyphosate (Roundup) to be applied to emerged alfalfa at any growth stage without the risk of crop damage. By applying glyphosate according to the size of the weed, and not the crop, weeds can be controlled early in the life of the alfalfa stand before they compete with and damage the crop, a problem that exists with conventional alfalfa herbicide programs. For more information, see HERBICIDE-TOLERANT VARIETIES AS A WEED MANAGEMENT STRATEGY.

WEED MANAGAMENET AFTER PLANTING

Preemergence herbicides for use after alfalfa emergence must be water-incorporated by sprinklers or rainfall. Preemergence herbicides used postplant do not normally persist in the soil longer than 6 weeks under cropping conditions; cool soil in winter can prolong activity by a few weeks. Be sure to check labels for grazing and harvesting restrictions.

By far the most common means of controlling weeds in seedling alfalfa is to apply postemergence herbicides after the crop and weeds have emerged. The economic returns of an appropriate, well-timed postemergence herbicide application are usually realized in the first harvest alone and may continue with additional harvests. Timing application in relation to the crop plant size (see below) and weed size is very important; best results are obtained when weeds are small (cotyledon to 2nd leaf) and growing vigorously. The most commonly used herbicides in seedling alfalfa are: imazamox (Raptor), imazethapyr (Pursuit), 2,4-DB (Butryac) and bromoxynil (Maestro). These herbicides are used alone or in tank-mix combinations depending on the weed species present. The selective grass herbicides clethodim (Select Max) or sethoxydim (Poast) are often used if grassy weeds are present. Use selective grass herbicides alone or in combination with the broadleaf herbicides mentioned above. The risk of crop injury may be increased with some tank mixes when adding an oil adjuvant in high temperatures. See the table below to learn about some of the characteristics of postemergence herbicides, application timing, and phytotoxicity symptoms.

Seedling Alfalfa Treatment Stage



From Canevari, W. M.; Colbert, W.; Lanini, W. T.; Orr, J. P. 2002. *Postemergence Weed Control in Seedling Alfalfa and Phytotoxicity Symptoms*, UC ANR Publication 21615.

Herbicide Guide for Seedling Alfalfa.[1]

Herbicide active ingredient (Example trade name)	Activity	Soil-residual properties	Minimum alfalfa growth stage for herbicide application	Recommended weed growth stage for herbicide application	Herbicide symptoms on alfalfa[2]	Herbicide symptoms on weeds
2,4-DB (Butyrac)	systemic (foliar)	no	second trifoliolate leaf	broadleaf weeds should be 3 inches tall or less	leaf narrowing and plant twisting may occur with higher rates, rain or when used with oil adjuvant or NIS surfactants; epinasty	twisting, epinasty, chlorosis in 1 to 10 days
bromoxynil (Maestro)	contact	no	second trifoliolate leaf	broadleaf weeds should be 2 inches diameter or less	chlorosis and burn beginning on leaf margins across entire leaf; symptoms show within 1 to 2 days, especially when temperatures reach 80ºF or higher. Caution using oil adjuvants	browning and necrosis within 2 to 4 days
clethodim (Select Max)	systemic (foliar)	no	first trifoliolate leaf	grass weeds 2 to 6 inches tall, vigorously growing before tillers develop	none observed; some discoloration from oil adjuvant in hot temperatures	chlorosis followed by necrosis at growing point in 6 to 10 days
glyphosate (Roundup) (For Roundup Ready alfalfa only)	systemic (foliar)	no	any stage	broadleaf and grass weeds, less than 6 inches tall and vigorously growing	none to minor	leaf chlorosis followed by necrosis in 1 to 2 weeks; symptoms are slowed in cold weather
hexazinone (Velpar)	some contact; mostly root uptake	yes	sixth trifoliolate leaf, with multiple stems and root length greater than 6 inches; rate limited	postemergence and preemergence activity on small broadleaf weeds less than 2 inches tall	leaf burn and chlorosis; small alfalfa seedlings may be killed	chlorosis and necrosis in 1 to 2 weeks
imazamox (Raptor)	systemic (foliar and root uptake)	yes	second trifoliolate leaf	broadleaf and grass weeds, less than 3 inches tall and vigorously growing	temporary growth reduction; mild chlorosis	chlorosis followed by necrosis in 2 to 4 weeks; symptoms are slowed in cold weather
imazethapyr (Pursuit)	systemic (foliar and root uptake)	yes	second trifoliolate leaf	broadleaf weeds and some grass weeds, less than 3 inches tall and vigorously growing	temporary growth reduction; mild chlorosis	chlorosis followed by necrosis in 2 to 4 weeks; symptoms are slowed in cold weather
paraquat (Gramoxone)	contact	no	third to sixth trifoliolate leaf; adjuvants can	small broadleaf weeds 1 to 3 inches tall and	bleaching to browning of leaf (foliage burn) is expected; stand	leaf bleaching and necrosis; in 1 to 3 days

Herbicide active ingredient (Example trade name)	Activity	Soil-residual properties	Minimum alfalfa growth stage for herbicide application	Recommended weed growth stage for herbicide application	Herbicide symptoms on alfalfa[2]	Herbicide symptoms on weeds
			enhance plant injury	grasses to 6 inches tall	reduction occurs on smaller seedlings with less than three trifoliolate leaves	
sethoxydim (Poast)	systemic (foliar)	no	first trifoliolate leaf	grass weeds 2 to 6 inches tall, vigorously growing before tillers develop	none observed; some discoloration from oil adjuvant with hot temperatures	chlorosis followed by necrosis at growing point in 6 to 10 days

[1] Adapted from Canevari, W. M. et. al. 2002. Postemergence Weed Control in Seedling Alfalfa and Phytotoxicity Symptoms, UC ANR Publication 21615.

[2] For more information on herbicide symptoms in alfalfa, see the Herbicide Symptoms Database (available online).

Clipping, Cutting, and Grazing

Avoid early forage removal unless weeds are dense enough to overtop (shade) and smother the alfalfa and cause stand loss. If weeds do become established and shade out the young alfalfa stand, the weedy alfalfa mix can be swathed early to remove the weeds and promote sunlight penetration to the young alfalfa. Clipping the top two-thirds of the canopy under weedy conditions may assist newly established alfalfa seedlings because cutting inhibits growth of most broadleaf weeds, which allows alfalfa regrowth to compete more successfully. Use caution when removing the forage early so that swaths do not damage young plants and wheel traffic does not compact wet soil.

In many areas, sheep grazing is used to remove winter annual weeds from new alfalfa plantings. Grazing can be worthwhile if these requirements are met:

- The alfalfa is large enough (three to four stems) to prevent sheep from uprooting the crop.
- The soil is dry (be ready to move sheep off the field in case of rain).
- The sheep are left long enough to eat all the weeds, but not so long as to cause soil compaction, or to trample over-graze, or crush young alfalfa seedlings.

For more information on weed management in alfalfa, see *Irrigated Alfalfa Management for Mediterranean and Desert Zones*, UC ANR Publication 3512.

COMMON AND SCIENTIFIC NAMES OF WEEDS IN SEEDLING ALFALFA (4/24)

Common Name	Scientific Name
Amaranth, Palmer	*Amaranthus palmeri*
Barley, hare	*Hordeum murinum* subsp. *leporinum*
Barnyardgrass	*Echinochloa crus-galli*
Bluegrass, annual	*Poa annua*
Brome, ripgut	*Bromus rigidus*
Burclover	*Medicago polymorpha*
Buttercup	*Ranunculus californicus*
Canarygrass	*Phalaris* sp.
Celery, wild	*Ciclospermum leptophyllum*
Chickweed, common	*Stellaria media*
Cocklebur, common	*Xanthium strumarium*
Dock, curly (seedling)	*Rumex crispus*
Dovefoot	*Geranium molle*
Fescue, rattail	*Vulpia myuros*
Fiddleneck	*Amsinckia intermedia*
Filarees	*Erodium* spp.
Fleabane, hairy	*Conyza bonariensis*
Foxtail, yellow and green	*Setaria* spp.
Goosegrass	*Eleusine indica*
Groundsel, common	*Senecio vulgaris*
Henbit	*Lamium amplexicaule*
Jimsonweed	*Datura stramonium*
Knotweeds	*Polygonum* spp.
Kochia	*Kochia scoparia*
Lambsquarters, common	*Chenopodium album*
Lettuce, prickly	*Lactuca serriola*
Mallow, little (cheeseweed)	*Malva parviflora*
Milkthistle	*Silybum marianum*
Miner's lettuce	*Claytonia perfoliata*
Mustard, black	*Brassica nigra*
Nettle, burning	*Urtica urens*
Nightshade, hairy	*Solanum sarrachoides*
Oat, wild	*Avena fatua*
Oxtongue, bristly	*Picris echioides*
Pigweeds	*Amaranthus* spp.
Pineapple-weed	*Chamomilla suaveolens*
Punagrass	*Achnatherum brachychaetum*
Radish, wild	*Raphanus raphanistrum*
Redmaids (desert rockpurslane)	*Calandrinia ciliata*
Rocket, London	*Sisymbrium irio*
Rush, toad	*Juncus bufonius*
Ryegrass, Italian	*Lolium multiflorum*
Shepherd's-purse	*Capsella bursa-pastoris*
Smartweed, water	*Polygonum amphibium* var. *emersum*

Common Name	Scientific Name
Sowthistle	*Sonchus oleraceus*
Speedwell, thymeleaf	*Veronica serpyllifolia*
Spurge, petty	*Euphorbia peplus*
Spurry, corn	*Spergula arvensis*
Starthistle, yellow	*Centaurea solstitialis*
Sunflower, yellow	*Helianthus annuus*
Swinecress	*Coronopus* spp.
Thistle, Russian	*Salsola* spp.
Wheat, volunteer	*Triticum aestivum*
Willowherb	*Epilobium* spp.

SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL IN SEEDLING ALFALFA (4/24)

	POSTEMERGENCE																
	24DB*[1]	24DB*[2]	24DB*[3]	24DB*[4]	BRO[1]	BRO[2]	CLE[1]	CLE[2]	GLY+	HEX	IMA[1]	IMA[2]	IMZ[1]	IMZ[2]	PAR*	SET[1]	SET[2]
Mode of Action	4	4	4	4	6	6	1	1	9	5	2	2	2	2	22	1	1
BROADLEAF WEEDS																	
Burclover	N	—	N	N	N	N	N	N	P	P	N	N	N	N	N	N	N
Buttercup	N	—	N	N	N	N	N	N	—	—	C	C	P	C	C	N	N
Celery, Wild	N	—	N	N	N	N	N	N	C	P	N	N	N	N	P	N	N
Chickweed	N	—	N	N	N	N	N	N	C	P	C	C	C	C	C	N	N
Cocklebur	C	—	C	C	C	C	N	N	C	C	C	C	C	C	P	N	N
Dock, Curly (seedling)	P	—	C	C	N	N	N	N	C	N	N	P	N	N	N	N	N
Dovefoot	N	—	N	P	N	N	N	N	C	—	C	C	C	C	C	N	N
Fiddleneck	N	—	N	N	C	C	N	N	P	P	N	P	N	P	P	N	N
Filarees	N	—	N	N	N	N	N	N	P	P	P	C	P	C	P	N	N
Fleabane	P	—	—	—	—	—	N	—	C	—	—	—	—	—	—	—	—
Groundsel, Common	N	—	P	C	P	C	N	N	C	C	N	N	N	N	P	N	N
Henbit	N	—	N	N	N	N	N	N	C	N	N	P	P	C	N	N	N
Jimsonweed	P	—	C	C	C	C	N	N	C	—	C	C	C	C	C	N	N
Knotweed (seedling)	N	—	P	C	P	P	N	N	C	C	P	C	P	C	N	N	N
Lambsquarters	C	—	C	C	C	C	N	N	C	C	N	N	P	C	C	N	N
Lettuce, Miners	N	—	N	N	N	N	N	N	C	P	C	C	P	C	C	N	N
Lettuce, Prickly	P	—	C	C	P	C	N	N	C	N	N	N	N	N	C	N	N
Mallow, Little (cheeseweed)	N	—	N	N	N	N	N	N	P	N	P	C	P	C	N	N	N
Milkthistle	N	—	N	P	N	P	N	N	C	—	N	N	N	N	P	N	N
Mustard, Black	N	—	P	C	C	C	N	N	C	P	C	C	C	C	P	N	N
Nettle, Burning	N	—	N	P	N	N	N	N	P	N	P	C	P	C	N	N	N
Nightshade, Hairy	P	—	C	C	C	C	N	N	C	C	C	C	C	C	C	N	N
Oxtongue, Bristly	—	—	P	P	P	C	N	N	—	—	N	P	—	—	—	N	N
Pineappleweed	N	—	N	N	N	P	N	N	C	P	N	N	N	N	C	N	N
Pigweed, Redroot	C	—	C	C	N	P	N	N	C	C	C	C	C	C	N	N	N
Radish, Wild	N	—	P	C	N	P	N	N	C	P	P	C	P	C	P	N	N
Rockpurslane, Desert	N	—	N	N	N	N	N	N	C	N	C	C	N	N	C	N	N
Rocket, London	P	—	C	C	P	C	N	N	C	P	C	C	C	C	C	N	N
Rush, Toad	N	—	N	N	—	—	N	N	C	C	C	C	—	—	N	N	N
Shepherd's-Purse	N	—	P	P	C	C	N	N	C	P	P	C	C	C	P	N	N
Smartweed, Swamp	P	—	C	C	P	C	N	N	C	C	C	C	—	C	P	N	N
Sowthistle	P	—	C	C	C	C	N	N	C	N	N	N	—	—	C	N	N
Speedwell, Thymeleaf	N	—	N	N	N	N	N	N	C	N	N	N	N	N	N	N	N
Spurge, Petty	N	—	N	N	N	—	N	N	—	—	C	C	—	—	C	N	N
Spurry, Corn	N	—	N	N	N	N	N	N	C	C	N	N	—	—	C	N	N
Starthistle, Yellow	N	—	N	N	P	C	N	N	—	C	N	N	—	—	C	N	N
Sunflower, Wild	C	—	C	C	C	C	N	N	C	C	C	C	C	C	P	N	N
Swinecress	N	—	N	P	N	P	N	N	C	C	C	C	—	—	P	N	N
Willowherb, Panicle	P	—	C	C	N	—	N	N	—	—	C	C	—	—	N	N	N
GRASS WEEDS																	

	POSTEMERGENCE																
	24DB*[1]	24DB*[2]	24DB*[3]	24DB*[4]	BRO[1]	BRO[2]	CLE[1]	CLE[2]	GLY+	HEX	IMA[1]	IMA[2]	IMZ[1]	IMZ[2]	PAR*	SET[1]	SET[2]
Barley, Hare	N	N	N	N	N	N	C	C	C	N	N	N	C	C	P	C	P
Barnyardgrass	N	N	N	N	N	N	C	C	C	N	C	C	C	C	P	C	C
Bluegrass, Annual	N	N	N	N	N	N	P	C	C	P	N	P	N	P	C	N	N
Brome, Ripgut	N	N	N	N	N	N	C	C	C	N	N	N	C	C	P	P	—
Canarygrass, Hood	N	N	N	N	N	N	C	C	C	N	N	P	C	C	P	C	C
Fescue, Rattail	N	N	N	N	N	N	—	C	C	N	N	N	P	P	P	N	P
Foxtail, Yellow	N	N	N	N	N	N	P	C	C	N	N	P	C	C	P	C	C
Goosegrass	N	N	N	N	N	N	P	P	C	N	N	N	N	N	N	P	P
Oat, Wild	N	N	N	N	N	N	C	C	C	N	P	P	C	C	P	C	C
Punagrass	N	N	N	N	N	N	P	C	P	N	N	N	N	N	N	P	C
Ryegrass, Italian	N	N	N	N	N	N	C	C	C/P^	N	N	N	C	C	C	C	C
Wheat, Volunteer	N	N	N	N	N	N	C	C	C	N	N	P	C	C	C	C	C

24DB*[1]	= 2,4-DB* (Butyrac 0.5)	MOA: 4	HEX	= hexazinone (Velpar 0.25)	MOA: 5	
24DB*[2]	= 2,4-DB* (Butyrac 0.75)	MOA: 4	IMA[1]	= imazethapyr (Pursuit 0.063)	MOA: 2	
24DB*[3]	= 2,4-DB* (Butyrac 1.0)	MOA: 4	IMA[2]	= imazethapyr (Pursuit 0.094)	MOA: 2	
24DB*[4]	= 2,4-DB* (Butyrac 1.5)	MOA: 4	IMZ[1]	= imazamox (Raptor 0.031)	MOA: 2	
BRO[1]	= bromoxynil (Maestro 0.25)	MOA: 6	IMZ[2]	= imazamox (Raptor 0.047)	MOA: 2	
BRO[2]	= bromoxynil (Maestro 0.375)	MOA: 6	PAR*	= paraquat (Gramoxone)	MOA: 22	
CLE[1]	= clethodim (Select Max 0.1)	MOA: 1	SET[1]	= sethoxydim (Poast 0.375)	MOA: 1	
CLE[2]	= clethodim (Select Max 0.24)	MOA: 1	SET[2]	= sethoxydim (Poast 0.46)	MOA: 1	
GLY+	= glyphosate (Roundup WeatherMax)	MOA: 9				

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

\+ For use in Roundup Ready alfalfa only.

1 Not usually applied at times suitable for controlling winter weeds.

∇ 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://wssa.net.

HERBICIDE TREATMENT TABLE FOR SEEDLING ALFALFA (4/24)

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

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

PREPLANT

After weeds emerge

A. GLYPHOSATE
(Roundup PowerMax) — Label rates — 4 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 9
COMMENTS: In conventional alfalfa, apply any time before planting to kill existing weeds. No soil residue. Do not mow or till before application. Do not apply just before rain or irrigation. High rate for annuals is only suggested for filaree control.

B. PARAQUAT*
(Gramoxone SL 3.0) — 0.6718–1.3952 lb a.i. / 1.3–2.7 pt — 24 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22
COMMENTS: Apply to emerged weeds. Do not use in soils that lack clay minerals, i.e., peat, muck, or pure sand. See label for use restrictions based on county or region. Always use a nonionic surfactant or crop oil concentrate with paraquat.

C. PELARGONIC ACID
(Scythe) — 3–10% volume/volume — 12 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 27
COMMENTS: A nonselective contact herbicide for control of emerged weeds. Can be used any time before alfalfa emergence. Weed size and growth stage determine the rate needed for control; will not control established perennials. This herbicide can also be used during winter dormancy to control winter weeds but cool weather reduces its efficacy. Because this is a contact herbicide, good spray coverage is essential for satisfactory weed control.

POSTPLANT

A. 2,4-DB*
(Butyrac 200) — 0.5–1.5 lb a.i. / 1–3 qt — 48 — 60
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 4
COMMENTS: A foliar-applied systemic herbicide that has no soil residual. Apply when alfalfa is in the second trifoliolate leaf stage. Broadleaf weeds should be 3 inches or less. Weed control increases with clear and warm conditions. If significant rainfall or irrigation occurs before 4 days after application, crop injury may occur. Can be combined with sethoxydim (Poast), clethodim (Select Max), bromoxynil (Maestro), imazethapyr (Pursuit), or imazamox (Raptor). When mixed with herbicide requiring an adjuvant, nonionic surfactants have shown to be less crop injurious than oil concentrates. Restricted use from Mar 15 to Oct 15 in some Central Valley counties. Check with your county agricultural commissioner. *Alfalfa injury symptoms:* leaf narrowing and plant twisting. *Weed symptoms:* twisting, epinasty and chlorosis in 2 to 10 days.

B. BROMOXYNIL
(Maestro 2EC) — 0.25–0.375 lb a.i. / 1.0–1.5 pt — 24 — see label
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 6
COMMENTS: A contact herbicide that has no soil residual. Apply when alfalfa has a minimum of 2 trifoliolates. Broadleaf weeds should not exceed 4-leaf stage, 2 inches in height or 1 inch in diameter. Thorough coverage is essential for best control. Do not apply when temperatures exceed 80°F. Combining with sethoxydim (Poast), clethodim (Select Max), imazethapyr (Pursuit), imazamox (Raptor), or 2,4-DB (Butyrac) will broaden control. When combined with the herbicides requiring oil adjuvants, crop injury will increase. Nonionic surfactants have shown to be less injurious to crop than oil concentrates. *Alfalfa injury symptoms:* leaf burn. *Weed symptoms:* browning and necrosis within 2 to 4 days.

C. CLETHODIM — 0.068–0.2425 lb a.i.

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
	(Select Max)	9–32 fl oz	24	15
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1			
	COMMENTS: A systemic herbicide with no soil residual. Apply when alfalfa is in the first trifoliolate leaf stage. Control is best when alfalfa is in the 3rd trifoliolate leaf stage and grass weeds are between 2 to 6 inches tall, growing vigorously before tillers develop. Control is reduced when grasses are moisture-stressed. Oil adjuvant or nonionic surfactant is required (see label for specific requirements). Can be combined with bromoxynil (Maestro), 2,4-DB (Butyrac), imazethapyr (Pursuit), and imazamox (Raptor) herbicides. Oil concentrate adjuvant will increase crop injury when mixed with bromoxynil (Maestro) or 2,4-DB (Butyrac). *Alfalfa injury symptoms:* none observed. *Weed symptoms:* chlorosis followed by necrosis at growing point in 6 to 10 days.			
D.	GLYPHOSATE (Roundup Ready alfalfa only)			
	(Roundup Powermax)	Label rates	4	5
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 9			
	COMMENTS: In Roundup Ready varieties, over-the-top applications can be made at any stage of growth. Do not use more than 132 fl oz/acre per year.			
E.	HEXAZINONE	0.25–0.375 lb a.i		
	(Velpar L CU)	1–1.5 pt	48	30
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 5			
	COMMENTS: A contact herbicide that also has soil residual. Use caution on sandy soil. Apply when alfalfa is between the sixth to ninth trifoliolate leaf stage with multiple stems, and root length is greater than 6 inches. Has both pre- and postemergence activity on small broadleaf weeds less than 2 inches in size. See label for additional restrictions. Useful tank mixes include sethoxydim (Poast) and clethodim (Select Max). *Alfalfa injury symptoms:* leaf burn and chlorosis. *Weed symptoms:* chlorosis and necrosis in 1 to 2 weeks.			
F.	IMAZAMOX	0.031–0.047 lb a.i.		
	(Raptor)	4–6 fl oz	4	0
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 2			
	COMMENTS: A systemic herbicide with soil residual that controls broadleaf and grass weeds. Has the same mode of action as imazethapyr (Pursuit), and it is not recommended that these two products be applied alternately. Apply when alfalfa is at least in the second trifoliolate leaf stage. Control is best when broadleaf weeds and grass weeds are less than 3 inches in height and growing vigorously. Control is reduced when weeds are moisture-stressed. Does not adequately control prickly lettuce, annual sowthistle, lambsquarters, and fiddleneck but can be tank mixed with another herbicide to broaden the spectrum of weeds controlled. Must use an adjuvant and a nitrogen-based fertilizer additive such as ammonium sulfate or urea ammonium nitrate (UAN). Useful tank mixes include bromoxynil (Maestro) and 2,4-DB (Butyrac). Oil adjuvants will increase the potential of crop injury when used with bromoxynil (Maestro) or 2,4-DB (Butyrac). Using a nonionic surfactant may be a safer choice. *Alfalfa injury symptoms:* temporary growth reduction. *Weed symptoms:* chlorosis followed by necrosis in 1 to 2 weeks.			
G.	IMAZETHAPYR	0.047–0.094 lb a.i.		
	(Pursuit)	3–6 oz	4	30
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 2			
	COMMENTS: A systemic herbicide with soil residual. Apply when alfalfa is at least in the second trifoliolate leaf stage. Control is best when broadleaf weeds and some grass weeds are less than 3 inches in height and growing vigorously. Weed control is greatly reduced when plants are moisture stressed. Can be combined with sethoxydim (Poast), clethodim (Select Max), bromoxynil (Maestro), imazamox (Raptor), or 2,4-DB (Butyrac) herbicides. Oil adjuvants will increase the potential of crop injury when used with bromoxynil (Maestro) or 2,4-DB (Butyrac). Using a nonionic surfactant may be a safer choice. *Alfalfa injury symptoms:* temporary growth reduction. *Weed symptoms:* chlorosis followed by necrosis in 1 to 2 weeks.			
H.	PARAQUAT*	0.3617–0.6718 lb a.i.		
	(Gramoxone SL 3.0)	0.7–1.3 pt	12	70
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22			
	COMMENTS: A contact herbicide that has no soil residual. **Due to risk of crop injury, use only as a rescue treatment when other options have failed.** Apply when alfalfa is in the third trifoliolate leaf stage or later. Broadleaf weeds should be between 1 to 3 inches and grasses below 6 inches. Thorough coverage is essential for best control. Rate increases with larger alfalfa plant size: use the 0.7 pt rate (0.3617 lb a.i.) if alfalfa has at least 6 trifoliolate leaves and 1.3 pt rate (0.6718 lb a.i.) if alfalfa has 9 trifoliolate leaves. Tank mixing information with other herbicides is limited. Always use a nonionic surfactant or crop oil concentrate. *Alfalfa injury symptoms:* leaf bleaching to browning. Stand reduction on smaller seedlings. *Weed symptoms:* bleaching and necrosis in 1 to 3 days.			
I.	SETHOXYDIM	0.09-0.46875 lb a.i.		
	(Poast)	0.5–2.5 pt	12	See label
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
COMMENTS: A systemic herbicide that has no soil residual. Can be applied when alfalfa is in the first trifoliolate leaf stage. Control is best when alfalfa is in the 3rd trifoliolate leaf stage and grass weeds are between 2-6 inches tall, growing vigorously before tillers develop. Control is reduced when grasses are moisture-stressed. Oil adjuvant is required. Can be combined with bromoxynil (Maestro), 2,4-DB (Butyrac), imazethapyr (Pursuit), and imazamox (Raptor) herbicides. Oil concentrate adjuvant will increase crop injury when mixed with bromoxynil (Maestro) or 2,4-DB (Butyrac). *Alfalfa injury symptoms:* none observed. *Weed symptoms:* chlorosis followed by necrosis at growing point in 6 to 10 days.			

‡ 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 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://wssa.net.

NA Not applicable

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

Weeds

Management in Established Alfalfa

(Section reviewed 3/17)

INTEGRATED WEED MANAGEMENT IN ESTABLISHED ALFALFA (3/17)

Uncontrolled weeds in alfalfa can seriously reduce yield as well as quality and retail value of alfalfa hay because some weeds are less palatable to livestock and less nutritious than alfalfa. The presence of poisonous weeds in hay, such as common groundsel, fiddleneck, and hemlock further lower the value or make it totally unmarketable. Tough, fibrous weeds may damage equipment during harvesting. Weeds that retain moisture can cause rotting or start fires in stored hay.

The need for an herbicide application depends on weed species, their competitiveness and toxicity to livestock, the potential market for the alfalfa, and time of year. Vigor of the alfalfa stand is an important factor; weakened stands are less competitive with weeds and will require an herbicide application when denser stands occasionally do not. Weeds are managed with adjustments of cutting schedules, cultivation in winter, grazing, irrigation, interplantings of other legumes or grasses, and herbicides.

MONITORING

Monitor for weed seedlings just after alfalfa is cut. Most winter annual weeds start to germinate in late September or October and continue to germinate until late January whenever soil moisture and temperature conditions permit. Summer annual weeds, especially grasses, start to germinate in early February (late March or April in the Intermountain Region) and can continue to germinate until midsummer with each irrigation. Survey for weeds in winter, summer, and early fall after alfalfa has been cut. Record observations on a monitoring form (*available online*).

Knowing which weeds are present is fundamental to planning an effective weed control program. Weeds are easiest to identify when full grown and flowering; seedling weeds can be difficult to identify. Many weed control decisions, however, must be made early, on the basis of identifying weed seedlings. Recording weed history in your field will assist in identifying weeds each year.

CUTTING SCHEDULES

Short cutting intervals (alfalfa reaching only the bud stage between cuts) reduce alfalfa vigor and encourage weed growth. Cutting alfalfa on longer schedules (letting it reach 60% regrowth with buds averaging 0.75 inch long or in the Intermountain Region when alfalfa is in the late bud to early bloom stage) keeps the alfalfa vigorous and competitive with weeds. However, high quality hay for dairy cows should be cut before any flowers appear, or when very few crown buds have started to grow. Cutting schedules are thus a compromise between producing high quality hay and maintaining a strong competitive alfalfa stand. Precise cutting schedules are hard to recommend because the growth rate of alfalfa depends on location and time of year. Often, a staggered approach to harvest schedules is recommended so that early-cut alfalfa is followed by a longer cutting period. This allows adequate recovery by the roots and a more vigorous stand.

Delay the first cutting of a fall-planted seedling field at least 2 to 3 weeks past the normal cutting date for established stands. The interval between the first and second cutting of a new alfalfa stand should be about 2 weeks longer than normal. This allows root reserves to build up, keeping the alfalfa vigorous.

CULTURAL CONTROLS IN WINTER

Established alfalfa is sometimes cultivated with a spring-toothed harrow during late winter. Such cultivations uproot weed seedlings but may also injure alfalfa crowns; crown injuries can delay the first cutting, reduce yields, and permit invasion of crown diseases. Winter cultivation is a practice that is usually most appropriate for organic alfalfa.

Grazing ("sheeping-off") or green-chopping fall and winter alfalfa growth can aid chemical weed control by exposing the soil and seedling weeds. A large number of animals should graze a field rapidly. If the grower only allows the animals to graze until the forage removed approximates a cutting, alfalfa vigor can be maintained through winter. However, alfalfa should not be grazed repeatedly or continuously, because overgrazing can deplete root reserves, reduce crop vigor, and lead to a thin, weedy alfalfa stand. Also, avoid grazing too early in fall or when the field is excessively wet. Sheep that have grazed dodder-infested fields or fields with sclerotinia can bring in seed or sclerotia, respectively. Therefore, they should be taken to an alternative area for a few days before grazing another alfalfa field.

CULTURAL CONTROLS IN SUMMER

Irrigate fields as shortly before harvest as practical. This allows the alfalfa time to regrow after harvest before an irrigation is needed, thus reducing the threat of root rot or scald. In addition, the soil can dry out after harvest, thus minimizing weed germination at the time when the alfalfa canopy is missing. Delaying irrigation following a harvest also helps suppress summer annual grasses by giving the alfalfa time to grow back and shade the ground; this is more difficult to accomplish on sandy soil than on loamy or clay soils.

Flaming vegetation with a propane or diesel burner can provide satisfactory control of dodder. Foliage should be as dry as possible for flaming. Observe all agricultural burn regulations.

INTERPLANTING GRASSES OR LEGUMES

Oats and other annual or perennial grasses or clovers can be planted into older, declining alfalfa stands to increase yields and suppress weeds without the use of herbicides. This is done typically in stands with sparse alfalfa populations. Plant grasses in December or January, during alfalfa dormancy, or after sheeping-off the alfalfa. In the cold, northeastern part of California, plant grasses in March or early April or in early fall. Interplanting with perennial grass can often extend stand life for more than one year, but results in a mix between grasses and alfalfa, changing the marketed product.

The best oat-seeding rate is approximately 50 to 60 pounds per acre depending on the alfalfa density. Broadcast oats, then disc or use a spring-tooth harrow to cover the seed. Or harrow the ground first, then use a grain drill to plant. To help oat growth, add nitrogen at 30 to 40 pounds per acre. The combination of oat competition and harrowing or disking at planting will suppress most weeds. An awnless wheat or barley variety can also be used instead of oats.

Fine-stemmed, leafy small grain varieties produce the most valuable forage. Cut small grain-alfalfa forage when the alfalfa would usually be cut. This cutting will be about 15 to 50% small grain,

depending on the alfalfa stand density and vigor. Small grain plants that are cut before heading are likely to regrow during the next cutting cycle, adding to the next yield, which may or may not be desirable depending on the intended market.

Orchardgrass is the most common perennial grass seeded into alfalfa. Orchardgrass and alfalfa mixtures are often in high demand by the horse industry. However, as a cool-season grass, orchardgrass is not well adapted to the hotter areas of California. Tall fescue and ryegrass can also be interseeded into thin alfalfa stands, but they are often too competitive and difficult to maintain the desired alfalfa and grass mixture.

Overseeding clovers offers several advantages over grasses, including higher crude protein and lower fiber, which makes the harvest suitable for dairy markets. Berseem clover is best adapted for California conditions and significantly increases yield for the first three to four harvests in the Central Valley. Berseem is primarily fall-planted, from September to early November with mid-October being optimal. Berseem is overseeded at 6 to 10 pounds per acre and planted shallow (less than 0.5 inch). Inoculating the seed with *Rhizobium trifolii* is recommended before planting. Because of vigorous winter growth of Berseem, earlier harvests than usual are necessary and could be problematic if rains occur. The forage is often difficult to cure so alfalfa and berseem mixtures are usually fed as silage or greenchop.

Overseeding perennial red clover can extend the life of a depleted alfalfa stand for 2 years or more and maintain the integrity of legume hay. Seedbed preparation is similar to that used when planting Berseem clover. Red clover should be planted about the same time as alfalfa would be planted, using a 6- to 12-pound per acre seeding rate.

For additional information on interplanting, see *Overseeding and Companion Planting in Alfalfa*, UC ANR Publication 21594.

HERBICIDES

Herbicides are used along with proper cultural weed control techniques to obtain effective, economical weed control. If winter annuals need to be controlled, apply preemergence herbicides in established alfalfa in fall or winter before new growth begins and before weeds become established. Preemergence herbicides must be incorporated by winter rainfall or sprinkler irrigation. Some herbicides with soil activity can cause yellowing of foliage and delay the first cutting when used on alfalfa that has resumed growth. In California's southern desert valleys where nondormant varieties of alfalfa grow year-round, some preemergence herbicides with soil activity cannot be used.

Some postemergence herbicides, such as paraquat, work on contact, so complete coverage is necessary. Stage of weed growth is also important; young weeds are usually easier to kill.

The use of transgenic alfalfa varieties such as Roundup Ready alfalfa allows glyphosate (Roundup) to be applied to emerged alfalfa at any growth stage without the risk of significant crop damage. For more information, see *Roundup Ready Alfalfa: An Emerging Technology*, UC ANR Publication 8153.

For more information on alfalfa herbicides, see *Alfalfa Management for Mediterranean and Desert Zones*, UC ANR Publication 3512.

SPECIAL WEED PROBLEMS IN ESTABLISHED ALFALFA

(3/17)

WEEDS POISONOUS TO LIVESTOCK

Several weed species found in California alfalfa fields are poisonous to livestock. The most common are fiddleneck, common groundsel, poison hemlock, and yellow starthistle. Many other weeds, and even some crop plants, may accumulate high levels of nitrates from nitrogen sources, which are dangerous to cattle and hogs but not to horses or sheep. Some plants (sorghum, sudangrass, nightshade, pigweed, curly dock) accumulate nitrates during stress by drought, lack of sulfur or phosphorus, or unusual weather such as low temperatures or warm spring weather followed by a long cold spell. Plants that are injured but not killed by phenoxy-type herbicides such as 2,4-DB may also accumulate nitrates. Plants that accumulate nitrates during stress will convert nitrates into safe compounds after the stress period is over.

SUMMER GRASSES

Summer grasses, like barnyardgrass, yellow and green foxtail, crabgrass, and southwest cupgrass, are a major problem in many alfalfa stands. To reduce their numbers, keep the alfalfa growing vigorously with proper irrigation and allow enough time between cuttings to maintain crop vigor. Invading grasses often occur on tail-ends of fields due to ponding of water and death of alfalfa stands. Because different species of summer grass weeds may germinate at different times during spring and summer, a field infested with several grass weeds may require repeated applications of herbicides to provide adequate control.

Summer grasses can be controlled before emergence in established alfalfa with trifluralin (Treflan) or pendimethalin (Prowl H2O). Apply from December to February before grasses begin to germinate (March until July). February is the typical cutoff to apply trifluralin or pendimethalin in the Central Valley, but they can be applied up to early April in the Intermountain Region. In the Low Desert, apply after the February cutting. Fields where trifluralin was applied must receive rain or irrigation within 3 days; moisture incorporates the herbicide. The allowable interval between application and incorporation is considerably longer with pendimethalin than trifluralin.

A less common alternative to control some grasses and nutsedge is EPTC (Eptam). It can be applied as a liquid into irrigation water or applied prior to irrigation using the dry granular formulation. The liquid formulation requires uniform metering of the herbicide into water during irrigation. Light irrigations on uniform, well-leveled soils are best. Apply before grasses germinate in mid-February for the Central Valley, or after a February or March cutting in the Low Desert. One application can control grasses for 30 to 45 days. The first application should be 3 pounds active ingredient per acre. Later applications of 2 pounds active ingredient per acre are necessary after the third and fourth cuttings. Read label for precautions concerning disposal of drainage water.

In a field where summer grasses have already germinated, apply sethoxydim (Poast) or clethodim (Select Max) to small grass seedlings in spring after the first or second cutting. Early application, before grasses become large and well-tillered, has proved most effective; May to June is an appropriate time for application in the Central Valley and the Low Desert and June and early July in the Intermountain Region. The field should be cut, irrigated, and then sprayed within 2 to 4 days. At this time, grasses are actively growing and alfalfa growth won't interfere with spray coverage. Use a crop oil or methylated

seed oil adjuvant. Two applications may be needed in a season. In Roundup Ready alfalfa, glyphosate (Roundup) provides effective control.

NUTSEDGE

Yellow and purple nutsedge can seriously affect weak alfalfa stands, especially in sandy soils. When sethoxydim (Poast) or clethodim (Select Max) has been used to remove a thick population of summer grasses, it may leave thin spots in the field; if nutsedge is present, it will take advantage of such open areas. Sethoxydim and clethodim do not control nutsedge.

Roundup Ready alfalfa also provides an excellent management opportunity to control nutsedge. Research trials conducted in the Central Valley have demonstrated that 1 to 2 applications of glyphosate (early and midseason) during the growing season adequately controlled and reduced the long-term population of nutsedge.

Apply EPTC (Eptam) in irrigation water or use a granular formulation to control nutsedge. The liquid formulation requires uniform metering of the herbicide into water during irrigation.

Halosulfuron (Sandea) can be used for postemergence control of nutsedge in established alfalfa. However, it can cause temporary stunting and yellowing of the crop when applied during the growing season in the Sacramento and San Joaquin valleys. Application of this product causes less injury and yield loss in the low desert regions of California.

The use of herbicides in rotational crops such as barley, cotton, corn, and in fallow fields can also be helpful in reducing populations of yellow nutsedge. To reduce yellow nutsedge to a manageable level, it will be necessary use selective herbicides (e.g., glyphosate or halosulfuron) in a crop rotational system for several seasons.

JOHNSONGRASS

Johnsongrass, a troublesome perennial weed, is not controlled by most alfalfa herbicides. Sethoxydim (Poast) and clethodim (Select Max) will control seedlings and should help to control established Johnsongrass. Johnsongrass is very susceptible to sethoxydim or clethodim applied when the grass is shorter than 12 to 18 inches. Multiple (two to three) herbicide applications are required for long-term control and eradication. Watch for new infestations developing from seeds in the soil. EPTC controls Johnsongrass emerging from seed but only suppress growth of established plants for several weeks. In Roundup Ready alfalfa, two applications of glyphosate (Roundup) provides effective control.

DODDER

Dodder, a yellow-orange, threadlike parasitic weed, can seriously affect alfalfa fields. It has no roots and derives water and nutrition directly from the alfalfa plant. Dodder can be controlled culturally, chemically, and by flaming. A dense, vigorous stand of alfalfa discourages dodder, as it requires sunlight to germinate. A dodder infestation can be suppressed or killed by cutting the alfalfa below the point at which dodder is attached but a normal swather cutting height is too high to eliminate dodder.

In established alfalfa, trifluralin in the granular formulation or pendimethalin liquid formulation, will effectively control dodder when applied prior to its emergence. In the Central Valley, dodder germinates from mid-February through June, so preemergence herbicides need to be applied, and water incorporated, prior to dodder emergence. Two 20 pound applications (2 lb a.i.) of granular trifluralin per acre (February and April) or 3 to 4 lbs a.i. of pendimethalin in February provide dodder control into

June. Other herbicides, such as imazethapyr (Pursuit) and imazamox (Raptor) can be applied in seedling alfalfa to control dodder once it emerges and before too much twining and attachment around the alfalfa plant occurs. In Roundup Ready alfalfa, glyphosate is very effective at controlling dodder once it germinates and before the dodder becomes too thick for complete spray coverage and penetration into the crop canopy. Chateau and Shark are herbicides that burn foliage on contact; they may offer some control of dodder but have not been fully tested. For best results with postemergence herbicides, apply to emerging dodder plants early before large mats of dodder are formed.

Flaming or nonselective herbicides can control dodder after it is attached to the alfalfa. For effective control, the alfalfa stems and foliage must be killed below the point of dodder attachment. Repeat herbicide applications may be necessary after each cutting, as dodder continues to germinate through most of the growing season (through August). To help prevent reinfestation and reduce the seedbank, apply an herbicide before dodder begins to produce seed. A burning permit is required in certain areas of the state.

Flail mowing effectively controls attached dodder. It involves cutting the alfalfa at the ground surface after the bales have been removed. This practice is less time-consuming and less injurious to the stand than burning. However, it may be less practical in flood-irrigated fields because of difficulty in mowing over the borders.

Because dodder is especially difficult to manage, the best strategy for preventing widespread infestations from developing is to eliminate isolated patches as they appear. Dodder is generally not completely controlled by crop rotation because its seed is long-lasting; however, it does help reduce dodder numbers.

FIELD BINDWEED

Bindweed is best controlled before planting alfalfa. It can be controlled in previous crops, such as grains, with selective broadleaf herbicides. Alternatively, control bindweed in fallow fields with intensive tillage and nonselective (e.g., glyphosate) or phenoxy (e.g., 2,4-D, dicamba) herbicides. Fields infested with field bindweed should be planted in fall when the field bindweed is dormant or growing very slowly. A good stand of vigorously growing alfalfa competes effectively with field bindweed, especially when coupled with the frequent mowing that occurs in an established alfalfa field. In Roundup Ready alfalfa, glyphosate (Roundup) provides effective control.

BERMUDAGRASS

Bermudagrass is a troublesome perennial weed that may crowd out alfalfa stands. In seedling and established alfalfa, repeated applications of sethoxydim or clethodim will provide effective control. In Roundup Ready alfalfa, glyphosate (Roundup) provides effective control.

COMMON and SCIENTIFIC NAMES OF WEEDS IN ESTABLISHED ALFALFA (4/24)

Common Name	Scientific Name
Amaranth, Palmer	*Amaranthus palmeri*
Barley, foxtail	*Hordeum jubatum*
Barley, hare	*Hordeum murinum* subsp. *leporinum*
Barnyardgrass	*Echinochloa crus-galli*
Bermudagrass	*Cynodon dactylon*
Bindweed, field	*Convolvulus arvensis*
Bluegrass, annual	*Poa annua*
Bluegrass, bulbous	*Poa bulbosa*
Brome, downy	*Bromus tectorum*
Canarygrasses	*Phalaris* spp.
Chickweed, common	*Stellaria media*
Cupgrass, prairie	*Eriochloa contracta*
Dandelion	*Taraxacum officinale*
Dodders	*Cuscuta* spp.
Fiddlenecks	*Amsinckia* spp.
Filarees	*Erodium* spp.
Fleabane, hairy	*Conyza bonariensis*
Flixweed and tansy mustard	*Descurainia* spp.
Foxtails (yellow and green)	*Setaria* spp.
Goosefoot, nettleleaf	*Chenopodium murale*
Goosegrass	*Eleusine indica*
Groundsel, common	*Senecio vulgaris*
Johnsongrass	*Sorghum halepense*
Junglerice	*Echinochloa colona*
Knotweed, prostrate	*Polygonum aviculare*
Lambsquarters, common	*Chenopodium album*
Lettuce, prickly	*Lactuca serriola*
Mallow, little (cheeseweed)	*Malva parviflora*
Miner's lettuce	*Claytonia perfoliata*
Mustards	*Brassica* spp.
Nettle, burning	*Urtica urens*
Nightshades	*Solanum* spp.
Nutsedge, yellow	*Cyperus esculentus*
Oat, wild	Avena fatua
Pepperweeds	*Lepidium* spp.
Pigweeds	*Amaranthus* spp.
Plantain, buckhorn	*Plantago lanceolata*
Quackgrass	*Elytrigia repens*
Radish, wild	*Raphanus raphanistrum*
Redmaids (desert rockpurslane)	*Calandrinia ciliata*
Rocket, London	*Sisymbrium irio*
Ryegrass, Italian	*Lolium multiflorum*
Ryegrasses	*Lolium* spp.
Shepherd's-purse	*Capsella bursa-pastoris*
Sowthistles	*Sonchus* spp.
Starthistle, yellow	*Centaurea solstitialis*
Stinkgrass	*Eragrostis cilianensis*

Thistle, Russian	*Salsola tragus*
Witchgrass	*Panicum capillare*

SUSCEPTIBILITY OF WINTER WEEDS TO HERBICIDE CONTROL IN ESTABLISHED ALFALFA (4/24)

	24DB*	CAR	CLE	DIU	EPT	FLU	GLY+	HAL	HEX	IMA	MET	NOR	PAR*	PEN	SAF	SET	TRI[1]
Mode of Action	4	14	1	7	8	14	9	2	5	2	5	12	22	3	14	1	3
ANNUAL WEEDS																	
Barley, hare	N	N	C	P	P	—	C	—	P	N	C	C	C	C	N	P	C
Bluegrass, annual	N	N	C	C	C	P	C	—	P	P	P	C	P	C	N	N	C
Bluegrass, bulbous	N	N	N	N	—	—	C	—	P	N	C	—	C	—	N	N	P
Brome, downy	N	N	C	P	C	—	C	—	C	N	C	C	C	C	N	C	C
Canarygrasses	N	N	P	C	C	—	C	—	P	P	C	C	P	C	N	C	C
Cereal, volunteer	N	N	C	C	C	—	C	—	P	N	P	C	P	C	N	P	N
Chickweed, common	N	P	N	C	C	C	C	C	P	C	C	C	P	C	C	N	P
Fiddlenecks (seedling)	N	C	N	C	P	C	C	—	C	P	C	P	P	C	C	N	C
Filarees (seedling)	P	C	N	C	N	C	C	—	C	C	C	N	N	N	P	N	N
Fleabane, hairy	P	C	N	N	—	C	C	—	C	—	N	N	C	N	C	N	N
Flixweed	C	C	N	C	N	—	C	—	C	C	C	N	C	—	C	N	N
Groundsel, common	N	P	N	N	P	C	C	C	C	P	P	N	P	N	C	N	N
Lettuce, prickly	C	C	N	P	C	C	C	—	C	N	C	N	P	N	C	N	N
Mallow, little (cheeseweed) (seedling)	N	C	N	P	N	C	C	C	P	C	C	P	N	P	C	N	N
Miner's lettuce	N	P	N	C	N	C	C	C	C	C	—	P	C	—	C	N	C
Mustards	C	C	N	P	N	C	C	C	C	C	C	C	P	P	C	N	N
Nettle, burning	P	C	N	C	P	C	P	C	C	C	C	N	P	N	C	N	C
Oat, wild	N	N	C	N	C	C	C	—	P	P	N	C	P	P	N	C	N
Pepperweeds	C	—	N	C	N	N	P	—	P	C	C	N	C	N	—	N	N
Radish, wild	N	C	N	C	N	—	C	C	C	C	C	C	P	N	C	N	N
Rocket, London	P	C	N	C	P	C	C	C	C	C	C	C	C	P	C	N	N
Ryegrass, Italian	N	N	C	P	C	—	C/P^	—	C	N	C	C	C	C	N	C	C
Shepherd's-purse	P	C	N	C	P	C	C	C	C	C	C	C	P	P	C	N	N
Sowthistles	C	C	N	P	C	P	C	C	C	N	N	P	N	N	C	N	C
Starthistle, yellow	C	—	N	C	C	C	C	—	C	N	C	N	P	N	—	N	N

C = control P – partial control N = no control — = no information ^ = resistant ryegrass resistance developing in many crops.

NOTE: Weed size and spray coverage affect weed control as will herbicide rate, adjuvant type, spray volume, and environmental conditions.

24DB	= 2,4-DB* (Butyrac)	MOA: 4	IMA	= imazethapyr (Pursuit) (highest rate)	MOA: 2
CAR	=carfentrazone (Shark)	MOA: 14	MET	= metribuzin (Tricor DF)	MOA: 5
CLE	= clethodim (Select Max))	MOA: 1	NOR	= norflurazon (Solicam)	MOA: 12
DIU	= diuron (Karmex)	MOA: 7	PAR	= paraquat* (Gramoxone)	MOA: 22
EPT	= EPTC (Eptam)	MOA: 8	PEN	= pendimethalin (Prowl H2O)	MOA: 3
FLU	= flumioxazin (Chateau)	MOA: 14	SAF	=saflufenacil (Sharpen)	MOA: 14
GLY[1]	= glyphosate (Roundup)	MOA: 9	SET	= sethoxydim (Poast)	MOA: 1
HAL	= halosulfuron (Sandea)	MOA: 2	TRI	= trifluralin[1] (Trifluralin)	MOA: 3
HEX	= hexazinone (Velpar)	MOA: 5			

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

\+ For use in Roundup Ready alfalfa only.

1 Not usually applied at times suitable for controlling winter weeds.

∇ 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://wssa.net

SUSCEPTIBILITY OF SPRING AND SUMMER WEEDS TO HERBICIDE CONTROL IN ESTABLISHED ALFALFA (4/24)

	24DB*	CAR	CLE	DIU	EPT	FLU	GLY+	HAL	HEX	IMA	MET	NOR	PAR*	PEN	SAF	SET	TRI[1]
Mode of Action	4	14	1	7	8	14	9	2	5	2	5	12	22	3	14	1	3
ANNUAL WEEDS																	
Barnyardgrass	N	N	C	P	C	—	C	—	P	C	C	C	P	C	N	C	C
Cupgrass, prairie	N	N	C	P	P	—	C	—	P	N	—	C	P	—	N	C	C
Dodders	N	P	N	N	N	—	C	—	N	P	N	N	P	C	P	N	C
Foxtail, green	N	N	C	C	C	—	C	—	C	C	P	C	—	—	N	C	C
Foxtail, yellow	N	N	C	P	C	—	C	—	C	C	P	C	N	C	N	C	C
Goosefoot, nettleleaf	C	—	N	C	C	C	C	—	C	P	C	C	C	C	N	N	C
Goosegrass	N	N	C	C	C	—	P	—	—	—	P	C	P	C	N	—	C
Junglerice	N	N	C	C	C	—	C	—	C	P	P	C	P	—	N	C	C
Knotweed, prostrate	P	C	N	C	P	C	C	—	C	C	N	P	P	C	C	N	C
Lambsquarters, common	C	C	N	C	C	C	C	N	C	P	P	P	N	C	C	N	P
Nightshades	C	C	N	C	C	C	C	N	C	C	N	C	P	N	C	N	N
Pigweeds	C	C	N	C	C	C	C	P	C	C	C	C	P	C	C	N	C
Stinkgrass	N	N	—	C	C	—	C	—	P	N	P	C	P	—	N	C	C
Thistle, Russian	P	C	N	N	P	—	C	—	P	P	P	C	P	P	C	N	P
Witchgrass	N	N	C	N	C	—	C	—	P	N	C	C	P	—	N	C	C
PERENNIAL WEEDS																	
Barley, foxtail	N	N	C	P	P	—	C	—	P	N	C	C	P	—	N	C	P
Bermudagrass (established)	N	N	P	N	N	—	C	N	N	N	N	P	N	N	N	P	N
Bermudagrass (seedling)	N	N	C	N	C	—	C	N	P	P	N	C	P	C	N	C	C
Bindweed, field (established)	P	N	N	N	N	N	P	N	N	N	N	N	N	N	N	N	P
Bindweed, field (seedling)	C	C	N	P	N	—	C	—	C	—	N	P	P	P	C	N	P
Dandelion (established)	C	P	N	N	N	—	C	—	P	N	P	N	P	N	P	N	N
Dandelion (seedling)	C	C	N	C	C	—	C	—	C	P	C	N	N	N	C	N	N
Johnsongrass (established)	N	N	C	N	N	—	C	—	N	P	N	C	N	N	N	C	N
Johnsongrass (seedling)	N	N	C	C	C	—	C	—	C	C	N	C	C	C	N	C	C
Nutsedge, yellow	N	N	N	N	P	P	P	C	N	P	P	P	N	N	N	N	N
Plantain, buckhorn (seedling)	C	C	N	C	—	—	C	—	C	—	—	—	C	—	C	N	—
Plantain, buckhorn (established)	P	N	N	N	—	—	P	—	P	N	N	N	N	N	N	N	N
Quackgrass	N	N	—	P	P	—	C	—	P	P	—	—	N	—	N	L	N

C = control P = partial control N = no control L = controlled according to herbicide label — = no information

NOTE: Weed size and spray coverage affect weed control as will herbicide rate, adjuvant type, spray volume, and environmental conditions.

24DB	= 2,4-DB* (Butyrac)	MOA: 4	IMA	= imazethapyr (Pursuit) (highest rate)	MOA: 2
CAR	= carfentrazone (Shark)	MOA: 14	MET	= metribuzin (Tricor DF)	MOA: 5
CLE	= clethodim (Select Max))	MOA: 1	CLE	NOR = norflurazon (Solicam)	MOA: 12
DIU	= diuron (Karmex)	MOA: 7	DIU	PAR = paraquat* (Gramoxone)	MOA: 22
EPT	= EPTC (Eptam)	MOA: 8	EPT	PEN = pendimethalin (Prowl H2O)	MOA: 3
FLU	= flumioxazin (Chateau)	MOA: 14	FLU	SAF = saflufenacil (Sharpen)	MOA: 14
GLY[1]	= glyphosate (Roundup)	MOA: 9	GLY[1]	SET = sethoxydim (Poast)	MOA: 1
HAL	= halosulfuron (Sandea)	MOA: 2	HAL	TRI = trifluralin[1] (Trifluralin)	MOA: 3
HEX	= hexazinone (Velpar)	MOA: 5	HEX		

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

\+ For use in Roundup Ready alfalfa only.

1 Not usually applied at times suitable for controlling winter weeds.

∇ 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://wssa.net/.

HERBICIDE TREATMENT TABLE FOR ESTABLISHED ALFALFA (4/24)

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

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

PREEMERGENCE (BEFORE WEEDS EMERGE)

A.	DIURON	1.2–2.4 lb a.i.		
	(Direx 4L)	1.2–2.4 qt	12	–
	(Karmex DF)	1.5–3 lb	12	–
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 7			
	COMMENTS: Apply after dormancy begins through January, but before weeds are well established. Apply only to stands 1 year or older. Do not replant treated areas within 1 year or 2 years if applied over 1.6 qt/acre (Direx 4L) or 2 lb/acre (Karmex DF). Do not use on coarse soils or in areas where crop does not go dormant. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas.			
B.	EPTC	2–3 lb a.i.		
	(Eptam 7E)	2.25–3.5 pt	12	14 (graze or harvest)
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 8			
	COMMENTS: Apply in spring before weed emergence. Apply as water-run. Use low rate on sandy soil, high rate on heavy soil. Repeat herbicide applications may be needed, up to 12.25 lb a.i. per season.			
C.	FLUMIOXAZIN	0.125 lb a.i.	12	25 (graze or harvest)
	(Chateau)	4 oz		
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14			
	COMMENTS: Apply to semi-dormant crop. It is most effective on broadleaf weeds and some grasses as a preemergence application. Apply prior to winter weed emergence (September–October) in the low deserts.			
D.	HEXAZINONE	0.495–1.5 lb a.i.		
	(Velpar L CU)	2–6 pt	48	30
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 5			
	COMMENTS: Apply during alfalfa dormancy. Do not use more than 0.5 lb a.i. on alfalfa less than 1 year old. Do not use on frozen ground or at high rates in high rainfall areas. Hexazinone is persistent in the soil and can injure crops following alfalfa. Follow label directions carefully; observe plantback restrictions.			
E.	METRIBUZIN	0.375–0.9975 lb a.i.		
	(Tricor DF)	0.5–1.33 lb	12	28 (graze or harvest)
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 5			
	COMMENTS: Apply in fall (during dormancy) or spring before new growth. Use on stands 1 year or older. Use only north of Interstate 80. Do not exceed 1 lb a.i./acre per season. Follow label directions carefully; observe plantback restrictions.			
F.	NORFLURAZON	1–1.965 lb a.i.		
	(Solicam DF)	1.25–2.5 lb	12	28
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 12			
	COMMENTS: Application may be made to both dormant and actively growing alfalfa. Will not control emerged weeds, only germinating weeds and nutsedge tubers. Rotational crops can only be planted at least 24 months after an application of this herbicide, and either a bioassay or test planting must be performed to test for remaining soil residues. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas.			
G.	PENDIMETHALIN	1.9–3.8 lb a.i.		
	(Prowl H2O)	2–4 qt	24	See comments
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3			
	COMMENTS: Apply before dodder and grass germination. Higher rates applied in January through February provide long season grass control into late summer (August). PHI is 14 days for forage or hay and 90 days for seed.			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
H. TRIFLURALIN	2 lb a.i.		
(Trifluralin 10G)	20 lb	12	21
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3			
COMMENTS: Apply before dodder and grass germination. Requires 0.5 inch rain or irrigation water within 3 days after an herbicide application. One application controls dodder into June; for longer control apply again after the first or second cutting.			
POSTEMERGENCE (AFTER WEEDS EMERGE)			
A. 2,4-DB*	0.5–1.5 lb a.i.		
(Butyrac 200)	1–3 qt	48	30 (graze or feed)
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 4			
COMMENTS: Apply when weeds are 3 inches or shorter. Rate varies with formulation and weed size. See label for grazing restrictions and regulatory restrictions for sensitive cropping areas. Apply when temperature is between 40°–90°F. Treated area should not receive irrigation or rainfall within 7 to 10 days. Restricted use from Mar 15 through Oct 15 in some Central Valley counties; check with your county agricultural commissioner.			
B. CARFENTRAZONE	0.008–0.04 lb a.i.		
(Shark EW)	0.5–2.5 fl oz	12	21 (forage or hay)
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14			
COMMENTS: Can be applied during the dormant period in winter or in season between cuttings for post emergence broadleaf weeds. In season application may result in a yield decrease between cuttings. Oil adjuvant will enhance herbicide activity.			
C. CLETHODIM	0.091–0.2425 lb a.i.		
(Select Max)	12–32 fl oz	24	15
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1			
COMMENTS: Do not apply within 15 days of grazing or harvest. Apply only to actively growing grasses at the height recommended on label. Use higher rate for perennial grasses, annual bluegrass, and under heavy grass pressure.			
D. GLYPHOSATE (Roundup Ready alfalfa only)			
(Roundup Powermax)	Label rates	4	5
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 9			
COMMENTS: In Roundup Ready alfalfa varieties, over-the-top applications can be made at any stage of growth. Do not use more than 132 fl oz/acre per year.			
E. HALOSULFURON	0. 0312–0.0468 lb a.i.		
(Sandea)	0.667–1 oz	12	14
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 2			
COMMENTS: Effective for postemergence control of nutsedge in established alfalfa. Can cause temporary stunting and yellowing of crop when applied during growing season in Sacramento and San Joaquin valleys. Less injury and yield loss results following applications in low desert region of California; crop injury is minimal and weed control best when applied in late summer (August–October) in the low deserts.			
F. HEXAZINONE	0.5–1.5 lb a.i		
(Velpar)	2–6 pt	48	30
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Weeds must be smaller than 2 inches tall or wide and receive 0.5 inch rainfall or irrigation to be effective post emergence. Do not use on alfalfa under stress. Use on dormant or slowly growing, healthy plants.			
G. IMAZAMOX	0.031–0.047 lb a.e.	4	0
(Raptor)	4–6 fl oz		
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 2			
COMMENTS: Has the same mode of action as imazethapyr, and it is not recommended that these two products be applied alternately. A systemic herbicide with short soil residual that controls broadleaf and grass weeds postemergence. Control is best when broadleaf weeds and grass weeds are less than 3 inches in height and growing vigorously. Control is reduced when weeds are moisture-stressed. Does not adequately control prickly lettuce, annual sowthistle, and fiddleneck but can be tank mixed with another herbicide to broaden the spectrum of weeds controlled and soil residual time. Some useful tank mix options are hexazinone, flumioxazin, and pendimethalin.			
H. IMAZETHAPYR	0.047–0.094 lb a.i.		

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
	(Pursuit)	3–6 oz	4	30 (graze, feed, or harvest)
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 2 COMMENTS: Apply when the weeds are 1 to 3 inches. Do not apply 12 months before the alfalfa is taken out of production because of plantback restrictions. Add a nonionic surfactant (0.25% v/v) or a crop oil concentrate (2 pt/acre). During winter months under cold conditions, use the highest label rate. Pursuit has postemergence and preemergence activity. Soil residual activity is considerably long (e.g., sugarbeets cannot be planted for 40 months). Postemergence herbicide activity is generally slow, up to 50 days. Use resistance management practices (i.e., alternate use with an herbicide of different chemistry).			
I.	PARAQUAT*			
	(Gramoxone SL 3.0)	Label rates	12	See label
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22 COMMENTS: Can be applied during dormant period in winter, rates vary depending on weed growth stage, crop leaf burn will occur but recovery is rapid. Gramoxone is commonly tank mixed with a soil residual herbicide to broaden the weed spectrum and increase the length of control. See label for grazing restrictions. Always use a nonionic surfactant with paraquat. Do not apply more than once per season.			
J.	SAFLUFENACIL	0.022–0.044 lb a.i		
	(Sharpen)	1–2 fl oz	12	See label
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14 COMMENTS: Used during the winter dormant period for emerged broadleaf weeds. Can be tank mixed with other post or pre emergence herbicides. Application timing should allow at least 75 days before first harvest. Oil adjuvant is required.			
K.	SETHOXYDIM	0.19–0.46 lb a.i.		
	(Poast)	1–2.5 pt	12	See comments
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1 COMMENTS: Apply when grass weeds have emerged but are still small. Add oil concentrate at 2 pint/acre. Irrigate before application or 2 days after. Preharvest interval is 7 days for grazing, feeding, or cutting for undried forage; 14 days for cutting for dry hay.			

‡ 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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[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://wssa.net.

Vertebrates
(Section reviewed 7/16)

MANAGING VERTEBRATES (7/16)

Vertebrate 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, however, can cause major problems by feeding on fruit and on tree bark, shoots, and roots, which can stunt growth or kill plants. Injury to trees by rodents or rabbits, for example, is often serious, killing the tree outright or causing permanent damage that lowers yields for years following the initial feeding.
Some pests will chew or destroy flexible irrigation lines and emitters. Other pests will dig holes through the soil surface, thereby channeling surface irrigation water to undesired areas. Food safety also becomes an issue if pest residues come into contact with the marketable commodity.

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

- Before planting, remove vertebrate pests and destroy habitats (such as burrows) within the field boundaries. Preventive measures cost less and are more successful before planting, when one can easily see the pests or their habitats.
- Be aware of the location, as vertebrate pests can easily reinvade if the field is adjacent to rangeland, waterways, or unmanaged areas. It is much easier to manage vertebrate pests by implementing 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.

	Control Measures								
Pest	Habitat modification	Trapping	Baiting	Fencing	Tree guards	Frightening	Shooting	Fumigating	Repellents
Deer				X	X	X	X[1]		X
Eastern fox squirrel		X					X		
Ground squirrel	X	X	X				X	X	
Pocket gophers	X	X	X					X	
Rabbits	X	X[2]	X	X	X		X		X
Rats	X	X	X					X	
Voles	X		X	X	X				
Coyote		X					X		
Wild pig		X		X			X		
Birds[3]	X	X		X		X	X		X

1 During hunting season or with a permit.

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

3 Not all of these techniques will be effective for all species. More specific information can be found in the bird section.

Adapted from Salmon and Lickliter 1984. Wildlife Pest Control Around Gardens and Homes. UC ANR Publication 21385.

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 materials, consult your local Cooperative Extension advisor or agricultural commissioner's office.

Legal Aspects of Vertebrate Pest Management

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

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

Pesticides

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

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

Trapping

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

Protected Species

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

Typical Guidelines

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

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

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

For more information on vertebrate management, see the Vertebrate Pest Control Handbook online (http://vpcrac.org/about/vertebrate-pest-handbook/).

CALIFORNIA GROUND SQUIRRELS (7/16)

Scientific Name: *Otospermophilus beecheyi* and *O. douglasii*

DESCRIPTION OF THE PEST

The adult California ground squirrel:

- Head and body 9 to 11 inches long
- Somewhat bushy tail is about as long as its body
- Fur is mottled dark and light brown or gray

Ground squirrels live in colonies that may grow very large if left uncontrolled. They are active during the cooler times on hot days and sunny periods during the cooler months; they are usually most active in morning and late afternoon. In periods of high winds, ground squirrels retreat to their burrows.

California ground squirrels live in underground burrows and form colonies of 2 to 20 or more animals. Each ground squirrel burrow system can have several openings with scattered soil in front. Individual ground squirrel burrows may be 5 to 30 feet long, 2.5 to 4 feet below the surface, and about 4 to 6 inches in diameter. Burrows provide the ground squirrels a place to retreat, sleep, hibernate, rear their young, and store food. Ground squirrels often dig their burrows along ditches and fencerows around buildings, within and bordering many agricultural crops, and on other uncultivated land. They tend to avoid flood irrigated areas, thick chaparral, dense woods, very moist areas, and lands that are under complete and frequent cultivation. They will travel 100 yards or more to feed in adjacent crops. When uncontrolled, they frequently move into perennial crops, such as orchards and vineyards, and dig burrows beneath the trees or vines.

The California ground squirrel can be active throughout the year in coastal areas of Southern California. Ground squirrels in the southern San Joaquin Valley become much less active during the winter, but seldom truly hibernate. Especially in hot locations, adult ground squirrels become temporarily dormant (estivate) when food is scarce or temperatures are extreme, primarily in late summer. Winter hibernation and summer estivation are more typical among ground squirrels in inland areas where temperature variations are more extreme. Regardless of location, young ground squirrels tend to be active all summer.

Ground squirrels that do hibernate generally emerge around January when weather begins to warm. In late winter and spring, they feed on green vegetation but switch to seeds and fruit in late spring and early summer as the vegetation dries up. Females have one litter, averaging 8 young, in spring. Young ground squirrels emerge from their burrow when about 6 weeks old; they do not estivate their first summer, and many may not hibernate during their first winter.

DAMAGE

California ground squirrels are responsible for major damage throughout the state. Their damage is most prevalent in crops adjacent to uncultivated areas where ground squirrels are not controlled.

- Adult ground squirrels often cache seeds and nuts in their burrows, especially in the late summer and early fall. During this period, crop losses greatly exceed the amount the ground squirrels have consumed. Ground squirrels also consume vegetative crops (e.g., alfalfa, cole crops, and lettuce) and berries.
- In addition to above ground damage, they can damage roots, enabling fungal pathogens to infect trees.

- They often chew plastic irrigation lines, and their burrows can contribute to soil erosion.
- When digging burrows, ground squirrels bring soil and rock to the surface and deposit it in mounds near burrow openings. They enlarge burrow systems each year by constructing new tunnels and creating more entrances, so the longer the ground squirrels occupy the burrow, the more extensive it becomes. They create more entrances to serve a growing population. Large and numerous burrow openings and soil mounds are hard on equipment and can make mechanical harvesting especially difficult.
- The burrows of ground squirrels can divert irrigation water and have been known to cause severe damage to levies and other water retention systems.
- In some areas, ground squirrels can also pose a health risk to humans through the spread of sylvatic plague.

MANAGEMENT

The management action needed for ground squirrels depends on their activity pattern and feeding preferences during the time of year when action is taken. The choice of tactics is also influenced by the location of the infestation and number of ground squirrels present. For more detailed information on managing ground squirrels, see Ground Squirrel Best Management Practices available online at http://www.groundsquirrelbmp.com/management-cgs.html.

Biological Control

Predators such as coyotes and hawks are usually not sufficient to effectively control ground squirrels. These predators consume a number of ground squirrels, but usually not enough to keep populations at sufficiently low numbers to eliminate the need for additional control measures.

Cultural Control

Habitat Modification

Ground squirrels often burrow beneath long-standing piles of prunings, wood, or rock, or use them as harborage. Removing such piles may make the area somewhat less desirable to them, but the base of trees, fence lines, and ditch banks still offer burrowing sites. Peripheral cleanup may somewhat reduce the potential for ground squirrels. In addition, it makes burrow detection and monitoring easier and improves access to burrows during control operations. Ground squirrels are extremely adaptable so habitat modification has limited benefit in a management program. Squirrels may quickly reinvade abandoned burrow systems. Deep plowing (ripping) along field perimeters will destroy burrow entrances and will help slow the rate of invasion. Burrow fumigants, toxic baits, and traps currently are the most effective control methods.

Monitoring and Treatment Decisions

To make it easier to monitor and help reduce numbers, remove brush piles, debris, and stumps in and around the crop fields. Monitor for ground squirrels year round, even in winter, especially during midmorning when they feed most actively. Monitor within the crop field during routine activities. Mid morning is usually the best time of day to observe squirrel activity.

To monitor:

1. Observe feeding grounds and watch for other signs of activity especially the appearance of burrows.
2. Check the perimeter of the crop fields at least once a month during the times of year when ground squirrels are active.

3. Periodically monitor areas from which ground squirrels are likely to invade, such as along ditch or road banks or in crops adjacent to your field.

Keep records and use them as the basis for future management decisions, noting:

- When ground squirrels emerge from hibernation
- When the first young are seen above ground
- Approximate number of ground squirrels you see and the location and number of burrows
- Changes in the general number of ground squirrels
- Management actions implemented, dates of use, and their effect

Treatment Options

When even one or two ground squirrels are present in or immediately adjacent to the crop field, be prepared to take action. Treatment options for ground squirrels include the use of fumigants (e.g., gas cartridges, aluminum phosphide,* and carbon monoxide-producing devices) and baiting with multiple-dose anticoagulants (e.g., chlorophacinone* and diphacinone*) or zinc phosphide*. These are restricted-use pesticides that require a permit from the county agricultural commissioner for purchase or use.

Select the control method best suited for the time of year.

- The most effective time to control ground squirrels is in late winter or early spring when adults have emerged from their burrows but before they reproduce. For best control, use burrow fumigation about 2 to 3 weeks after the first ground squirrels emerge from hibernation.
- Because ground squirrels feed almost exclusively on green vegetation early in the season, poisoned grain baits are generally not effective until late spring or early summer.
- Trapping can be used year round but is most effective when numbers are low.
- In late spring or summer, at locations where squirrels are moving from adjacent lands into the crop field to feed, baiting or trapping along the perimeter offers the most effective control if access to the neighboring property is not possible.

Fumigants

Fumigation can be very effective against ground squirrels. The best time to fumigate is late winter or early spring when the ground squirrels are active and soil is moist. Fumigation is also possible later in the year as long as sufficient soil moisture is present, although it is not effective when ground squirrels are hibernating or estivating: at those times, they seal themselves off from within their burrows. When the soil is dry, fumigation is much less effective because more of the toxic gas escapes from burrows through cracks in the soil.

When using a fumigant, make sure to treat all active burrow systems in and around the crop field. Recheck all areas a few days after fumigation and re-treat any that have been reopened. For safety's sake, do not fumigate burrow systems that are adjacent to buildings or may open under structures.

A relatively easy way to fumigate is with the use of gas cartridges. They are available commercially and from some county agricultural commissioners' offices. Use one or two cartridges for each burrow that shows signs of activity. A large burrow system may require more than two.

1. Quickly shove the ignited cartridge into the burrow using a shovel handle or stick and seal the burrow entrance with soil.
2. Watch nearby burrow entrances; treat and seal any that begin to leak smoke.

3. If smoke is observed escaping from other entrances, it means the burrows are connected. If the burrow is believed to be small, this additional entrance only needs to be sealed. If the burrow appears to be large, an additional cartridge may need to be inserted following the above-outlined protocol.

The larger and more complex the burrow system, the more smoke it takes to be effective.

Aluminum phosphide* is also a highly effective burrow fumigant. In fact, studies of this material for ground squirrel management indicate an efficacy of 95 to 100%. When aluminum phosphide* tablets come into contact with moist soil and air in the burrow they produce phosphine gas, which is highly toxic to any animal (never add water directly to the burrow to increase moisture as spontaneous combustion can occur if the product contacts water). When using aluminum phosphide*, treat every active burrow, fill the entrance with a wad of newspaper, and cover with soil. In addition to being somewhat more effective than gas cartridges, aluminum phosphide* is also much cheaper to apply. However, aluminum phosphide* is a highly restricted-use material, and these restrictions are frequently changing. Be sure to understand the current restrictions in place before using for ground squirrel control. Application personnel should be trained in the material's proper use and on its potential hazards.

As of 1 January 2012, pressurized exhaust machines can now be used to apply carbon monoxide to burrow systems. As of 2014, the author is aware of two commercial products available: the Pressurized Exhaust Rodent Controller (PERC®) machine and the Cheetah rodent control machine. Initial research into the efficacy of these devices has indicated that the PERC® is moderately effective for California ground squirrels, although results were highly variable. The Cheetah rodent control machine did not prove to be effective. Plans are in place to further test these devices in the future.

Baiting

Poison bait is usually the most cost-effective method for controlling ground squirrels, especially when numbers are high. Bait consists of grain or pellets treated with a poison registered for ground squirrel control. To be effective, bait must be used at a time of year when ground squirrels are feeding on seeds and will readily accept baits such as in late spring or early summer. In fall, ground squirrels store a lot of the seed instead of eating them, so it may require more bait to control the population.

Before you use baits, place a small amount of untreated grain, such as breakfast oats, near burrows in the morning and check in the late afternoon to see if the ground squirrels have taken it (this ensures that nocturnal animals have not eaten the grain). If the grain is taken during the day, proceed with baiting. If it is not taken, wait several days or a week and try again. Remember: bait is only effective if eaten by the target pest. If in a nut orchard, once squirrels begin feeding on nuts, they no longer show much interest in grain baits. Therefore, baiting programs must be initiated before this time to ensure effective control of ground squirrels. When using poison baits, make sure to follow label directions carefully to reduce hazards to nontarget species.

Multiple-dose anticoagulant baits (e.g., chlorophacinone* and diphacinone*) can be applied in bait stations, as spot treatments near burrows, or broadcast over larger infested areas. Check the label to make sure that the bait you plan to use is registered for the method you intend to use. For a multiple-dose bait to be effective, animals must feed on it over a period of 3 to 5 days so if spot or broadcast treatments are used, 2 or 3 applications may be necessary.

Zinc phosphide* is an acute toxicant that can also be use to control ground squirrels. It kills ground squirrels after a single feeding, so it can reduce numbers more quickly than anticoagulants. However,

zinc phosphide* has a distinctive odor and taste that many ground squirrels seem to avoid. Likewise, ground squirrels will occasionally consume a sublethal dose of zinc phosphide* that will cause individuals to get sick but will not kill them. This leads to bait shyness in a ground squirrel population. These problems with bait acceptance and bait shyness sometimes result in greater control of ground squirrels when using anticoagulant baits. Pre-baiting the area with untreated grain 2 to 3 days prior to the application of zinc phosphide* may reduce the chances of bait shyness and improve the effectiveness of baiting programs. Control with zinc phosphide* is usually achieved within 48 hours of the bait application.

Baits Applied as Broadcast or Spot Treatments

When specified on the label, zinc phosphide* and anticoagulant baits* can be applied as spot-treatments, which are economical and effective for small populations. Reapply according to label directions to make sure there is no interruption in exposure to the bait. Scattering the bait takes advantage of the ground squirrels' natural foraging behavior and minimizes risks to nontarget species that are not as effective at foraging for seeds. Never pile the bait on the ground because piles increase the hazard to livestock and certain nontarget wildlife.

When ground squirrel populations are larger or cover a broader area, broadcast applications of zinc phosphide* or anticoagulants* may be used. This can be an effective and economical method for controlling this species over a large area. Usually squirrels retreat back to burrows when sick and will die there, although up to 20 to 30% of ground squirrels may die aboveground.

Baits Applied in Bait Stations

Various kinds of bait stations are commonly used with diphacinone* and chlorophacinone* 0.005% baits; all are designed to let ground squirrels in but to exclude larger animals. Special types of stations must be used within the ranges of the San Joaquin kit fox or endangered kangaroo rats to ensure that these species are excluded. Consult your local agricultural commissioner or the California Department of Pesticide Regulation website (http://www.cdpr.ca.gov/docs/endspec/) for the latest recommendations on use of poison baits in areas that are within the range of endangered species.

1. Place bait stations near runways or burrows and secure them so they cannot easily be tipped over. If ground squirrels are moving into the crop field from adjacent areas, place bait stations along the perimeter of the field where ground squirrels are invading, one station every 100 feet. Use shorter intervals between stations when the number of ground squirrels is high.

2. Check bait stations daily at first, then as often as needed to keep the bait replenished. If bait feeding is interrupted, the bait's effectiveness will be greatly decreased. Make sure to pick up any bait that spills and to replace bait that is wet or moldy. Successful baiting usually requires 2 to 4 weeks. Continue to supply bait until feeding ceases and you observe no ground squirrels; then remove and properly dispose of unused bait if there is not a threat on continued reinvasion.

3. Zinc phosphide* cannot be used in bait stations.

After treatment, pick up and dispose of any carcasses whenever possible to prevent secondary poisoning of dogs or other scavengers. Burial is a good method for disposal as long as the carcasses are buried deep enough to discourage scavengers. Do not touch dead animals with bare hands.

Assess the potential hazard to humans, livestock, and nontarget wildlife before you use baits; if it is risky, use another method for ground squirrel control.

Trapping

Because trapping is time-consuming, it is most practical for small infestations any time of year when ground squirrels are active. Trapping is especially effective from mid-spring through fall. Ground squirrel traps include Conibear traps and modified gopher box traps. As with all traps, take precautions to minimize trapping of nontarget wildlife and pets.

Conibear Traps

Conibear kill traps are usually placed unbaited in the burrow entrance, where ground squirrels are trapped as they pass through. Trap effectiveness can be increased by putting a tunnel of roofing paper (24 inches long) at the entrance of the burrow. The ground squirrel will mistake the light at the end of the tunnel for the burrow opening and run full speed through the trap. The tunnel also minimizes any sun reflection off the metal trap.

If you are using this type of trap within the range of the San Joaquin kit fox, you must place the trap in a covered box with an entrance no larger than 3 inches wide to exclude the fox, or you must spring the traps at dusk and reset them again in the morning.

Box Traps

Modified wooden pocket gopher box traps consist of a pair of box traps that have been joined together by removing the backs, connecting the two traps with wire mesh, and then to a board. Another very effective trap is a single wooden box trap. The single wooden box trap (Critter Getter DK-3) is larger than the pocket gopher box trap (DK-2) and has a pull trigger rather than the push type for pocket gophers. The traps are baited with foods such as almonds, barley, melon rinds, oats, or walnuts. Place bait in traps well behind the trigger or tied to the trigger without setting the traps for several days, until the ground squirrels become used to taking the bait. Then put in fresh bait and set the traps. With the single pull trap, secure the bait to the trigger and wire the trap to a stake, fence, or other stationary object. Place traps so that nontarget animals are not likely to be caught. For example, place traps inside a larger box with openings no larger than 3 inches wide, just large enough to allow ground squirrels to enter.

Live Traps

Live-traps, such as wire-cage and multiple-capture traps, can also be used to capture ground squirrels. The Black Fox repeating live trap has proven to be very effective in catching several individuals at one time. This 24”x 24”x 4” heavy gauge wire trap has doors that are wired open for several days for pre-baiting. When the self-closing doors are dropped down after pre baiting, the ground squirrel pushes to get in but cannot get out. As with box traps, pistachios, almonds, walnuts, oats, barley, and many fruits and vegetables are all effective baits. Because these traps keep ground squirrels alive after capture, they are useful in areas where nontarget captures are a concern (e.g., areas with pets, children, etc.). However, ground squirrels must be euthanized by the trapper upon capture as translocation of ground squirrels is illegal unless in possession of a permit issued by the California Department of Fish and Wildlife, unloads your problem on others, and can spread disease such as sylvatic plague. It is this extra step that limits the utility of live-trapping for some growers. Methods considered humane by the American Veterinary Medical Association include: gassing with carbon dioxide and shooting. Drowning is not an approved method of euthanasia and is illegal in California. Traps need to be checked once daily, and any animals found must be removed and should be euthanized.

Gas Explosive Device

The use of a gas explosive device that combines propane with oxygen has been used to kill ground squirrels through concussive force. This device has the added benefit of destroying part or all of the ground squirrel's burrow system, thereby potentially slowing reinvasion rates. This control method carries with it a substantial fire hazard. To date no scientific studies have shown this method to be overly effective at ground squirrel control.

Repellents

No repellents have proven effective at substantially reducing damage caused by ground squirrels.

Frightening Devices

No frightening devices have proven effective at substantially reducing damage caused by ground squirrels.

* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.

POCKET GOPHERS (7/16)

Scientific Name: *Thomomys* spp.

DESCRIPTION OF THE PEST

Pocket gophers are stout-bodied rodents with short legs. Adults:

- 6 to 8 inches
- brown, gray, or yellowish
- large clawed front paws
- small ears and eyes
- a short, scantily haired tail

On each side of the mouth pocket gophers have external cheek pouches or "pockets" used extensively for carrying food.

Pocket gophers are rarely seen above ground. They live almost entirely underground spending most of their time in a tunnel system they construct 6 to 12 inches beneath the soil surface. A single burrow system can cover several hundred square feet and consists of main tunnels with lateral branches used for feeding or for pushing excavated soil to the surface. Because gophers are extremely territorial, you rarely find more than one gopher per burrow system, unless it is during the breeding season or females are tending their young.

The conspicuous, fan-shaped soil mounds over tunnel openings are the most obvious sign of a gopher infestation. These tunnel openings are almost always closed with a soil plug unless the gopher is actively excavating a tunnel.

Gophers feed primarily on the roots of herbaceous plants. They may also come aboveground to clip small plants within a few inches of the tunnel opening and pull vegetation into the burrow to eat.

Gophers breed throughout the year on irrigated land, with a peak in late winter or early spring. Females bear as many as three litters each year, although typically only one or two per year, each averaging five young. Once weaned, the young gophers travel to a favorable location to establish their own burrow system. Some take over previously vacated burrows. The buildup of gophers in crop fields is favored by extensive weed growth, including nutsedge, or the presence of many cover crops, especially perennial clovers and legumes.

DAMAGE

Pocket gophers can be serious pests. They are active throughout the year and if uncontrolled and food is plentiful, can increase to 30 to 40 gophers per acre; in alfalfa they can reach even greater numbers. Pocket gopher damage tends to be greatest in alfalfa; they will consume all parts of the plant, but damage is often centered on the roots and crown of the plant. This damage has been found to cause serious stand decline leading to a shorter harvest life of many fields statewide. Their mounds can also cause extensive damage to hay equipment, and dirt from the mounds can lower hay quality.

Pocket gophers also feed on the roots of vegetable and berry plants. Plants with more fibrous root systems often suffer minimal damage; plants with large taproots are most susceptible. Gophers sometimes gnaw on plastic irrigation lines. These holes lead to uneven water distribution, with some areas receiving too much water, and other parts not receiving any. Fixing pocket gopher punctures of

subsurface drip tape can be time-consuming and quite expensive. Tunnel systems often lead to a loss or diversion of irrigation water and may lead to severe erosion.

MANAGEMENT

Persistent efforts can control pocket gophers and even eliminate them. Pocket gopher damage typically occurs belowground; therefore, it often goes undetected until individual plants or trees exhibit stress. By that time the tree or plant may be beyond saving. Gopher activity is readily detected, however; just look for fresh mounds of soil. Gophers make the greatest numbers of fresh mounds in the spring and fall, when the soil is amply moist.

Take action as soon as you see any sign of gopher activity. Common control methods include trapping, aluminum phosphide* fumigation, or hand-applied poison bait. Trapping and hand-baiting can be used at any time of year, but they are easier when the soil is moist and not dry and hard; aluminum phosphide* must be used when the soil is moist. Control of vegetative cover can reduce the attractiveness of fields to gophers by removing preferred food sources (e.g., nutsedge, clovers, and legumes). In addition, consider managing gophers in adjacent areas to reduce the potential for gopher reinvasion.

Gopher control is best done in late fall through late winter when mounding activity is high. Additionally, because numbers are usually lowest during early winter, management during this time of year can be more effective than after gophers have reproduced.

Biological Control

Snakes, owls, and hawks are usually not sufficient to effectively control gophers. These predators consume a number of gophers but usually not enough to keep populations at low enough numbers to eliminate the need for additional control measures.

Cultural Control

Flood Irrigation

If flood irrigation is possible, it can help control gophers; they are not aquatic. This type of irrigation often drives gopher activity to the edges of the field where they are more easily located to control, if not killed by flooding. Growers and their dogs can also actively seek out voles at this time to further reduce population size.

Tilling

When taking a field out of production, deep tilling of soil will kill some gophers and destroy most or all burrow systems in a field. This can slow reinvasion rates and provides more time to get gopher populations under control.

Monitoring and Treatment Decisions

The best times to monitor for gopher activity are after irrigation and when mound building peaks in fall and spring.

- Monitor monthly.
- Pay close attention to field perimeters to determine whether gophers are invading the field from adjacent property.
- Monitor closely in weedy areas such as roadsides and in young orchards with extensive weed growth or ground cover. This type of vegetation is more likely to support gophers, and low-growing vegetation makes signs of burrowing activity more difficult to see.

- Look for darker-colored mounds, which indicate newly removed, moister soil.
- If you find mounds, trees or vines showing signs of stress, or both, look for girdling of roots or crowns at or below the soil.

Treatment Options

The preferred control methods are baiting with multiple-dose anticoagulants, strychnine* or zinc phosphide*; trapping; and burrow fumigation. Neither chemical nor mechanical repellents have been found effective against pocket gophers. Remove vegetative cover and preferred food sources (e.g., clovers and legumes) to reduce the attractiveness of cover crops in orchards and vineyards to gophers. Often, a single approach is not sufficient to effectively control gophers. An integrated approach that uses more than one control option should provide greater control.

Strychnine*, zinc phosphide*, anticoagulants*, and aluminum phosphide* are currently restricted materials that require a permit from the county agricultural commissioner for purchase or use in agricultural fields. Be aware that restrictions for use of baits and fumigants around buildings may exist. However, restriction criteria of baits and fumigants often change, so it is best to consult your local agricultural commissioner before using any baits or fumigants to assure full compliance with current laws and regulations.

All treatment options require access to the main tunnel, located about 6 to 12 inches belowground. Finding the main tunnel takes practice, skill, and the use of a probing device. To find a main tunnel:

1. Locate a fresh gopher mound. The key is to look for mounds that contain moist dirt.
2. Start by finding the plug of the mound.
3. Begin probing anywhere from 4 to 12 inches behind this plug.
4. You will know you have found the tunnel when you feel a drop in the probe (i.e., less resistance) of a couple of inches. Tunnels typically run in only one or two directions. Occasionally you will have tunnels running in three or more directions.

Baiting

While multi-dose anticoagulants (e.g., chlorophacinone* and diphacinone*) are available for gopher control, single-dose acute baits (e.g., strychnine* and zinc phosphide*) have historically been the most effective.

Gophers often back-fill old tunnels with loose soil and these backfilled tunnels can feel like open tunnels to inexperienced bait applicators. Applying bait in these backfilled tunnels will greatly limit the efficacy of this management approach; gophers will not find bait placed here.

Before initiating a baiting program, train all bait applicators to identify backfilled tunnel systems. An effective way to conduct this training is to:

1. Have novice bait applicators probe for open (non-back-filled) tunnel systems.
2. Once they have found a tunnel, they dig down into these tunnel systems to verify whether they are open or backfilled.
3. Repeat until the bait applicator successfully identifies open tunnel systems with at least 90% accuracy.

Following these methods should result in consistently more efficacious control efforts when using baits and burrow fumigants.

Apply bait below ground. For small infestations or where the use of a mechanical burrow builder is not feasible, use a probe to find the main tunnel next to a fresh mound or between two fresh mounds. Once you find the main tunnel

1. Enlarge the probe opening by rotating the probe back-and-forth
2. Place a small amount of grain or pelletized bait in the burrow; a funnel can also be used to pour the bait into the tunnel.
3. Place a dirt clod, stone, or another covering over the hole to keep out light and prevent soil from falling onto the bait.

Place bait in two or three places along the tunnel. This hand-application method can be used for single-dose or multiple-dose baits.

If gophers have infested a large area, reservoir-type hand probes designed to deposit single-dose baits are available. Bait application is faster with these devices because they eliminate the need to stop and place the bait by hand. Once you have located a tunnel using the probe, a trigger releases a measured amount of bait into the tunnel. It is important to check the probe periodically to make sure that is has not been clogged with soil. Generally, strychnine* or zinc phosphide* bait is used with such an applicator because it can dispense only a small quantity of bait at a time. Anticoagulant* baits are less toxic and require greater volumes of bait to be effective, thereby limiting the utility of bait probes for these baits.

A mechanical burrow builder can also be effective and economical for infestations that cover large areas. This device is pulled behind a tractor to construct artificial gopher tunnels into which it places bait. Artificial burrows either intercept some of the gopher's natural burrows, or the gopher will soon discover the artificial burrow and consume the bait. Prior to using this application device, it is important to know the average depth of active pocket gopher burrows before setting up the burrow builder. Use a probe to find burrows and a shovel to verify they are active (open). After starting the application, use a shovel to occasionally open a small section of the artificial burrow and inspect its depth and condition. It is also important that the compaction / drive wheels properly compact the soil over the burrow. Soil moisture is important, as tunnels created in dry soil will cave in, while tunnels created in wet soil may not form properly. Soil moisture must be intermediate to produce a well-formed, smooth, artificial burrow. Follow the manufacturer’s manual to properly set the depth and calibration of bait application. All baits used in burrow builders are restricted-use materials. Use of a mechanical burrow builder may be feasible in situations such as unplanted borders or between widely spaced young trees when the terrain is relatively level and the soil is not too rocky or before planting a field. However, because the burrow builder creates an extensive network of burrows, only use it when gopher numbers are high as these new burrows will increase the speed with which gophers can invade new areas.

Trapping

Traps are effective against small numbers of gophers but are labor intensive. As such, they can be relatively expensive to use over large acreage. However, trapping often results in greater control of gophers than baiting, so the cost may be offset by effectiveness. Use either pincher traps (most common) or box-type kill traps. The smaller size and lower cost of pincer traps typically makes them a more practical choice in a field setting. Pincher traps such as the Macabee, Cinch, or Gophinator have a vertical metal or wire pan which the gopher triggers by pushing against it. Studies have shown the Gophinator and Cinch traps to be more effective than other tested traps.

Pincher-type traps can be placed in the main tunnel of a gopher burrow system or in lateral tunnels. Setting traps in lateral tunnels is quicker and easier than trapping in the main tunnel. However, trapping

in lateral tunnels may be less effective at certain times of the year (e.g., summer) and for more experienced gophers (e.g., adult males).

To place traps in the main tunnel find a fresh mound and probe as described in the Treatment Decisions section. When found, clear out the tunnel until the opening is just wide enough to insert the traps. Place traps in the main tunnel, one facing each direction the tunnel goes.

1. Set traps and place them entirely into the tunnels. The number of traps required will depend on the number of tunnels present.
2. Stake the traps by fastening wire, light cable, or twine to the trap and stake to prevent predators from carrying away traps with catches. Stakes also serve as markers to indicate trap location.
3. You can cover up the trap-hole with sod, plywood, canvas, or some other material to keep light from entering the tunnel system. However, a recent study has shown that covering trap-holes has only a minor effect on capture success. When trapping a large area, leave trap-holes uncovered to save substantial time; however covering trap-holes may keep children and pets out of traps, if this is a concern.
4. If there is no evidence that a gopher has visited the trap within 24 hours, move it to a new location.

To place traps in lateral tunnels, remove the plug from a fresh mound and place the trap entirely into the lateral tunnel. In many areas, the plugs in these lateral tunnels are quite extensive; in these situations, trapping laterals becomes counterproductive given the extensive period of time required to remove these plugs.

Fumigants

Most fumigants, such as gas cartridges, are not effective because gophers quickly seal off their tunnels when they detect the smoke or poison gases. However, aluminum phosphide* can be effective if applied underground into tunnels during a time of year when soil is moist enough to retain the toxic gas, typically in late winter to early spring, or year round in irrigated crops. In fact, burrow fumigation with aluminum phosphide* is typically the most consistently efficacious option for gopher control as long as sufficient soil moisture is present.

Application of aluminum phosphide* is similar to hand-baiting.

1. Use a probe to locate the main tunnel.
2. Once the tunnel has been found, wiggle the probe to enlarge the hole large enough to dispense the aluminum phosphide* tablets into the tunnel.
3. Follow label instructions on the number of tablets to place into the tunnel.
4. Cover the probe hole with a rock or dirt clod, being careful not to bury the tablets under loose dirt.
5. Treat each tunnel system twice.

When using aluminum phosphide*, be sure to carefully follow all label directions and safety instructions.

As of 1 January 2012, the use of pressurized-exhaust machines that inject carbon monoxide into burrow systems has become a legal technique for controlling burrowing mammals in California. The California Department of Pesticide Regulation is now developing regulations for use of this method of control. This approach appears to be somewhat effective at controlling pocket gophers, although early studies have not shown it to be as effective as burrow fumigation with aluminum phosphide* or trapping.

Gas Explosive Device

The use of a gas explosive device that combines propane with oxygen has been used to kill gophers through a concussive force. This device has the added benefit of destroying part or all of the gopher's tunnel system, potentially slowing reinvasion rates. Exercise caution when using these devices because of the potential for unintended damage to property, injury to users and bystanders, potential for starting fires in dry environments, and destruction of turf. Additionally, these devices can be quite loud, making them unsuitable in residential areas. Studies on the efficacy of this device have not been positive. Alternative options such as burrow fumigation, trapping, and baiting appear to be more effective.

Repellents

No scientific data has been reported to show that chemical repellents effectively keep gophers from inhabiting fields, orchards, or vineyards. A new repellent for use in subsurface drip tape has been developed that may offer some promise although it has yet to be sufficiently tested to verify efficacy.

Frightening Devices

Frightening gophers with sound or vibrations also does not appear to be effective.

* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.

VOLES (MEADOW VOLE, MEADOW MICE) (7/16)

Scientific Name: *Microtus* spp.

DESCRIPTION OF THE PEST

Voles are also called meadow mice. Adults:

- Larger than house mice but smaller than rats
- Blunt-nosed stocky rodents
- Full grown length is 4 to 6 inches
- Small ears and eyes
- Short legs
- Short tails
- Coarse fur is usually dark gray or grayish brown

Compared to deer mice, voles have a more robust body, less obvious ears, and a relatively shorter tail. Vole ears are at least partly obscured by the hair in front of them and their tails are about one-half to one-quarter the length of their head and body combined. Deer mice have relatively large and prominent, fleshy ears, white belly and feet, and their tail is bi-colored and more than 70% the length of their head and body.

Voles live in colonies and are active both day and night, all year round. Females bear 5 to 10 litters per year, with peaks of reproduction in spring and fall. Because voles mature rapidly and bear multiple litters yearly, numbers can increase quickly reaching as high as hundreds of voles per acre. In many areas, populations peak every 4 to 8 years, and then decline fairly rapidly. Voles live in areas such as irrigated pastures, fencerows, or weedy ditchbanks, where the soil is suitable for burrowing and where vegetation provides cover. Grasses and other dense ground cover provide food and shelter that favor the buildup of vole populations. They usually avoid sandy soils. The soil of the Tulelake Basin of Northern California is a location that is highly favorable for voles.

You can recognize vole activity by the narrow runways in grass or other ground cover, connecting numerous shallow burrows with openings about 1-1/2 inches in diameter. Voles seldom travel far from their burrows and runways, usually less than 10 feet (3 m) from the nest. 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.

Five 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. In potatoes, most damage occurs in the Klamath Basin, where the montane vole (*M. montanus*) is found.

DAMAGE

If left unchecked, voles will cause extensive damage to alfalfa. This damage includes consumption of taproots and above-ground vegetation that can result in

- reduced vigor, mortality of alfalfa plants, or both
- loss of irrigation water down burrow systems
- chewing on underground drip lines

In winter where alfalfa goes dormant, vole damage to roots and crowns are often not apparent until green-up the following spring. As such, much care must be taken to ensure low vole numbers heading into winter.
as the burrows are very difficult to detect and bait as the crop matures.

MANAGEMENT

The best management programs for voles keep numbers at low levels; once vole numbers reach high levels, control becomes much more difficult and costly. Vegetation management and the proper use of exclusion keep damage to a minimum. Poisonous bait (either multiple-dose anticoagulants* or zinc phosphide*) can control voles that reach harmful numbers. All field-use rodenticides for voles are restricted use materials that require the applicator to be a private or commercial certified applicator or to be under the supervision of a certified applicator. Some require a permit from the county agricultural commissioner for purchase or use.

Biological Control

Predators such as coyotes, foxes, badgers, weasels, owls, and hawks feed on meadow voles; however, predation is rarely, if ever, a major factor in controlling a rapidly increasing vole population.

Cultural Control

Habitat Management

Because of the vegetative nature of alfalfa, habitat management is rarely a viable option in these crops.

Exclusion

Exclusionary fencing consisting of aluminum flashing can be used along field borders. The fencing should be buried at least 6 inches below ground and should extend 12 inches above ground. Drive rebar or wooden stakes into the ground every 15 feet to provide support for the fencing. The efficacy of such fencing is greatly increased if bare soil is present around the base of the fence. Be aware that equipment must frequently move in and out of fields, thereby limiting sites where fencing is practical. Fencing is expensive, so significant damage should be expected to justify the cost of installation.

Flood Irrigation

Where still feasible, flood irrigation can help control vole populations. When a field is flooded, the voles must come to the surface or drown. When at the surface, they can be picked off by a number of predators; growers and their dogs can also actively seek out voles at this time to further reduce population size.

Monitoring and Treatment Decisions

It is important to monitor for voles carefully. Otherwise, you may not notice damage until it is too late to prevent significant injury.

Make sure to check ditch banks, fencerows, roadsides, and other areas where permanent vegetation favors the buildup of voles. Dense grass is their preferred habitat.

Starting in midwinter, monitor monthly in cover crops, weedy areas, and alfalfa fields looking for:

- Active runways: 1- to 2-inch wide surface paths that lead to silver dollar-sized burrow openings.
- Place snap traps in runways to detect pests. Scatter around the field to identify active areas needing baiting. Use expanded trigger traps to avoid having to use bait.
- Fresh vole droppings and short pieces of clipped vegetation, especially grass stems, in runways.

Baiting

If you find damaging infestations or numbers increasing within orchard, vineyard, or vegetable crops, poison baits can be used during the dormant season to greatly reduce vole numbers. Baiting can also reduce voles in adjacent areas before they have a chance to invade. Single- and multiple-dose baits are available, but there may be baiting restrictions in some areas to protect endangered species. It is imperative that you understand and follow the label directions for use. In particular, please note that poison baits cannot be applied within orchard, vineyard, or vegetable crops from green up (spring) until after harvest occurs.

For small infestations, scatter the bait in or near active vole runways and burrows according to the label directions. For larger areas and where the label permits, you can make broadcast applications using a belly grinder-type seeder or a vehicle with a tailgate seeder. Broadcast application rates vary, depending upon estimated numbers of voles and type of toxicant. Both single-dose (e.g., zinc phosphide*) and multiple-dose (e.g., first-generation anticoagulants, chlorophacinone* and diphacinone*) poisons are used for meadow vole control in orchard, vineyard, and vegetable crops. These are restricted-use pesticides that require a permit from the county agricultural commissioner for purchase or use.

In ditchbanks and other non-cropland sites, bait should be applied in fall or spring before the voles' reproduction peaks to slow or prevent populations from expanding into the crop. However, application within an orchard, vineyard, or vegetable field is restricted to the nonbearing season, so timing is key to prevent a population explosion during the growing season. Bait acceptance will depend on the amount and kind of other food available. When baiting for voles with anticoagulants, you should remove all aboveground carcasses by burying them underground, or by bagging and disposing them in the trash. This will reduce potential secondary poisoning hazards.

Within alfalfa fields, only zinc phosphide* can be applied. Zinc phosphide* is applied directly to vole burrows and runways through spot treatments or broadcast applications. If overused, problems with bait shyness can occur. As such, zinc phosphide should not be applied more than once over a 6-month period. Additionally, zinc phosphide* must be applied when new growth is less than 2-inches tall. Carefully read the label for more information on restrictions for zinc phosphide* application in alfalfa.

Trapping

Trapping is not typically practical as voles often number in the thousands over even relatively small areas.

Fumigants

Fumigation is not typically effective because of the shallow, open nature of vole burrow systems and the large number of voles. However, it is occasionally used in artichokes given the deeper structure of vole burrow systems in the crop.

Repellents

Repellents are not effective in preventing damage.

* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.

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Precautions for Using Pesticides

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

Legal Responsibility

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

Transportation

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

Storage

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

Container Disposal

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

Protection of Nonpest Animals and Plants

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

Posting Treated Fields

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

Preharvest Intervals

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

Permit Requirements

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

Maximum residue levels

Before applying pesticides to crops destined for export, check maximum residue levels (MRLs) of importing country at http://globalmrl.com.

Processed Crops

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

Crop Injury

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

Personal Safety

Follow label directions carefully. Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. NEVER eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care IN ADVANCE as required by regulation.