Irrigated Alfalfa Management
for Mediterranean and Desert Zones

Producing Alfalfa Hay Organically

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UNIVERSITY OF CALIFORNIA
Division of Agriculture and Natural Resources
Publication 8307
6/2008
http://anrcatalog.ucdavis.edu

Chapter 21

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UC PEER REVIEWED

This publication is **Chapter 21** of a 24-chapter series on Irrigated Alfalfa Management published by the University of California Alfalfa & Forage Systems Workgroup. Citation: Long, R. F.; Meyer, R. D.; Orloff, S. B. 2008. Producing alfalfa hay organically. IN C. G. Summers and D. H. Putnam, eds., Irrigated alfalfa management in Mediterranean and Desert zones. Chapter 21. Oakland: University of California Agriculture and Natural Resources Publication 8307. See: http://alfalfa.ucdavis.edu/IrrigatedAlfalfa

Organic alfalfa hay production involves the growing, labeling, and marketing of alfalfa according to National Organic Program (NOP) standards as defined by the U.S. Department of Agriculture (USDA). These standards require that alfalfa be produced with approved inputs given in the national materials list with some brand names listed by the Washington State Department of Agriculture or the Organic Materials Review Institute. Farmers must also take precautions against pesticide drift and other sources of contaminants. In addition, hay handling equipment as well as storage areas must be designated organic or appropriately cleaned between conventional and organic use with documentation noted. Fields on which organic alfalfa is to be produced must be managed organically, with no prohibited substances applied for at least 3 years prior to being certified as organic.

Federal laws regulating organic products require producers to be certified organic through a USDA accredited certifier (public or private) and they must also register with the California Department of Food and Agriculture's Organic Program. This registration is handled through the County Agricultural Commissioner's Office throughout the state. The certification

process requires that the producer develop a written organic farm plan, known as the organic system plan (OSP), that describes how the farm is to be managed in accordance with USDA-NOP rules and subsequent approval of the plan by the certifier. In addition, yearly updates to the farm plan are required as well as yearly on-site farm audits by certifiers to ensure compliance with federal regulations.

Despite the extensive recordkeeping needed to produce alfalfa organically, the rise in the demand for feed makes alfalfa an attractive crop for some organic farmers where there can be an average 20 percent or more price premium over conventionally grown alfalfa hay (Fig. 21.1). This need for organic feed is primarily driven by the rise in demand for organic dairy products whereby cows producing organic milk must be fed organic feed. Other markets for organic alfalfa include organic beef and lamb production and hay for horses. Currently about 1 percent of California's total alfalfa hay production is organic, or about 10,000 acres.

Growing alfalfa organically can be quite challenging as compared with conventionally produced alfalfa hay. Unless properly established and managed, there can be a reduction in yield and quality associated with increased weed and pest pressure and maintaining adequate soil fertility. The purpose of this chapter is to provide information on how to produce alfalfa organically from the establishment to production phase. When in doubt about any farming practice allowed for organic crop production, check with the USDA guidelines, California Department of Food and Agriculture's organic program, or your certifier. For information on costs associated with organic alfalfa production, see http://coststudies.ucdavis.edu, UC Cooperative Extension, "Sample costs to establish and produce organic alfalfa hay in California."

Importance of Stand Establishment

The importance of stand establishment process for organic growers cannot be overemphasized. This includes especially (1) preplant irrigation to reduce weeds, (2) soil preparation and land leveling to improve irrigation efficiency, (3) proper time of planting in early fall to encourage good root development, (4) choice of a pest-resistant variety, and (5) sprinkler irrigation to produce good stands. These methods are all detailed in Chapter 4, "Alfalfa Stand Establishment," and are important for all growers. However, organic growers must have higher levels of management during the stand establishment process, since their subsequent weed and pest control options are fewer. The best protection for an alfalfa crop against pests and diseases is a dense, vigorous alfalfa stand, which has been established at the proper time. This is one of the most important strategies available to organic alfalfa growers to prevent weed intrusion and recover from other pests and crop stresses.

FIGURE 21.1

Organic alfalfa is favored by some growers where there may be a 20% or more price premium over conventionally grown alfalfa hay.

Land Preparation

The basic cultural requirements for alfalfa production are similar whether the crop is grown organically or conventionally. The ground should be worked in the fall, as soon as the previous crop is harvested, to prepare a seedbed. Fields should be disked and landplaned and borders pulled up for irrigation checks. Where better drainage and irrigation water distribution is desired, such as on clay soils, beds should be listed. Extra care should be taken to ensure that fields are leveled and well drained to prevent standing water and subsequent stand loss and weed problems.

Cultivar Selection and Planting

Variety selection is an important step when establishing alfalfa stands. Select the appropriate dormancy type and specific varieties that are resistant to insects and diseases found in your area. The National Alfalfa Alliance maintains a listing of marketed alfalfa varieties, including fall dormancy and pest resistance ratings (http://alfalfa.org). Remember however, alfalfa resistant varieties are not completely pest resistant so additional pest control measures may be needed in years of heavy pest pressure. See Chapter 5, "Choosing an Alfalfa Variety," for additional information. Selecting a variety that has a more nondormant characteristic with faster regrowth will also inhibit weed germination and establishment.

USDA standards require the use of organic seeds. In addition, the National Organic Program regulations prescribe that an organic availability search clause procedure be outlined and approved by the certifier before certification can be granted. This committed procedure must be followed unless approval has been granted to purchase nonorganic seeds. Conventionally grown seeds may be used as long as they are not genetically modified or chemically treated and there is clear documentation of "non-availability" of organic seed from several sources.

Inoculate the seed with the appropriate organically approved nitrogen-fixing bacteria (*Rhizobium* sp.) if alfalfa has not been grown in the area for at least 10 years. Use certified seed, as it will be nearly weed free. The best time to plant alfalfa is in the fall (September–October) to encourage vigorous stands that outcompete weeds. Seeding rates should be slightly higher than normal, for example, 25–30 pounds per acre (28–34 kg per hectare) to help further suppress weeds.

Fertility Management

Seedling Fields

Prior to planting alfalfa it is important to assess the fertility needs of the crop. See Chapter 6, "Alfalfa Fertilization Strategies," for a more complete discussion of assessing nutrient requirements of alfalfa. The NOP regulations also require the calculation of nutrient needs of the crop and how those needs will be met. The high costs of organic versus synthetic nutrients (4-6 times higher for phosphorus and 2–3 times higher for potassium) makes careful analysis imperative. Sample soils according to the guidelines in Chapter 6 to determine crop needs. Incorporate the recommended amounts of phosphorus and potassium as manure or other organically approved fertilizers into the soil (Table 21.1). If the soil pH is below 6.3, apply an organically approved liming material. For growers transitioning into organic alfalfa production with soils that require large amounts of lime, phosphorus, and potassium, it may be more economical to build up the soil fertility by adding synthetic fertilizers and focus on weed and insect control prior to the 3-year transition period to organic production.

Compared to commercial fertilizers such as 0-46-0, 11-52-0, or 0-0-60, organic manure and compost fertilizers have relatively low concentrations of actual nutrients which can vary, usually 0.5–3% each of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) (Table 21.1). In addition, most organically approved materials also have a wide range in moisture content (10–40% or more) so the quantity of nutrients applied must be adjusted based on the actual moisture content. For example, a ton of moist manure or compost may range from only 1,400 pounds (635 kg) of dry weight (30% moisture) up to as much as 1,800 pounds (816 kg) of dry

TABLE 21.1

Status of organic soil amendments and fertilizing materials†

Material[a]	Status[b]	Moisture (%)	$CaCO_3$ Equiv. (%)[c]	P_2O_5 (%)[c]	K_2O (%)[c]	S (%)[c]
Liming Materials						
Ash, Wood or Fly Ash—Plant and animal sources only. Fly ash is generally 3–50% organic matter. Ash from minerals, manure or prohibited materials (glue, plastics or synthetic substances) is prohibited. Manure ash is prohibited because burning manure is wasteful of organic matter and nutrients.	R	5–20	5–50	0.1–3.0	2.0–20	0.1–3.0
Limestone-mined, calcium carbonate	A[d]	5–10	50–90			
Dolomite-mined calcium, and magnesium carbonate	A[d, e]	5–10	50–95			
Sugarbeet lime	P	5–15	50–85			
Compost						
Compost—(plant and animal materials). Composted plant and animal materials produced through a process that: (i) establishes an initial C:N ratio of between 25:1 and 40:1 and (ii) maintains a temperature of between 131°F and 170°F for 3 days using an in-vessel or static aerated pile system; or (iii) maintains a temperature of between 131°F and 170°F for 15 days using a windrow composting system, during which period the composting materials must be turned a minimum of five times. Acceptable feedstocks include, but are not limited to, animal manure, by-products of agricultural commodities processing, and source-separated yard debris or "clean green."	A	1–50		0.1–2.0	0.3–2.0	0.1–0.3
Compost Tea—extracted from sewage sludge and prohibited synthetic nutrient sources is prohibited.	P					
Manure						
Manure—Composted (See Compost)	A	1–50		0.2–2.5	0.4–3.0	0.1–0.4
Manure—Raw animal—(Also manure or compost tea, slurry, lagoon water)—must be composted unless it is: (i) applied to land used for a crop not intended for human consumption, (ii) incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles, or (iii) incorporated into the soil not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles. Human waste products and sewage sludge are prohibited. Uncomposted manure can contain high levels of plant and human pathogens, weed seeds, volatile and soluble nitrogen and pesticide residues.	R	1–80		0.5–3.0	0.5–3.0	0.1–0.4
Macro and Secondary Nutrients						
Bone meal	A			10–25		
Guano	A			10–18		
Rock phosphate must not be fortified or processed with synthetic chemicals. Cannot be used in California if it originates from western United States sources.	A[d]			0.5–3.0[f]		
Potassium chloride (KCl) Muriate of potash—Only from mined sources. Shall be used in a manner that prevents excessive chloride in soils.	R[d]				60	
Potassium sulfate—nonsynthetic (synthetic or that produced by acidulation or chemical reaction is prohibited).	A[d]				50–52	18

TABLE 21.1 (continued)

Status of organic soil amendments and fertilizing materials†

Material[a]	Status[b]	Moisture (%)	$CaCO_3$ Equiv. (%)[c]	P_2O_5 (%)[c]	K_2O (%)[c]	S (%)[c]
Macro and Secondary Nutrients						
Sulfate of potash magnesia or potassium magnesium sulfate (Langbeinite)	A[d]				22	18
Sulfur-Elemental—as plant or soil amendment.	A[d]	5–10				95–99
Gypsum	A[d]	5–10				14–17
Micronutrients						
Synthetic, use restricted to cases where soil/plant nutrient deficiency is documented by soil or plant tissue testing: (i) soluble boron products, (ii) sulfates, carbonates, oxides or silicates of zinc, copper, iron, manganese or sodium molybdate. Ammonium molybdate is prohibited.	R					
Sewage Sludge, Biosolids	P					

† In California, a fertilizer is defined as a material having at least 5% by weight singly or in combination of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O).

[a] References are the USDA-NOP, 2003, Organic Materials Review Institute Generic Materials List, June 2004, and Washington Department of Agriculture organic materials list, March 2007.

[b] Status designations: **Allowed (A)** include nonsynthetic materials that are not specifically prohibited by NOP Rule Section 205.602 and synthetic materials that are specifically allowed by Section 205.601. **Restricted (R)** substances are allowed in organic production subject to NOP rule use restrictions. **Prohibited (P)** substances in crop production are generally defined in NOP Rule Section 205.105.

[c] Concentration is given on a 100% dry matter basis.

[d] A mined substance of low solubility.

[e] Dolomite contains both calcium and magnesium carbonate and excessive buildup of magnesium may be undesirable particularly on high magnesium soils. It is however, an excellent source of magnesium for soils low in magnesium.

[f] Total phosphorus content may range from approximately 18–25% but citrate and water-soluble phosphorus are much lower. Rock phosphate is almost completely ineffective on alkaline soils (pH greater 7.0) because soil acidity must dissolve the material before the phosphorus becomes available to plants. Also, the heavy metal concentrations prohibit the use of rock phosphate originating from western United States sources.

weight (10% moisture). As a result, if the phosphorus content is 1 percent P_2O_5, then there would be 14 pounds (6.4 kg) P_2O_5 per ton in a 30 percent moisture material, whereas a 10 percent moisture manure or compost would contain 18 pounds (8.2 kg) P_2O_5 per ton. If the manure or compost analysis is reported as phosphorus (P) instead of (P_2O_5) concentration, then multiply P by 2.29 to get the P_2O_5 content. Since suppliers give only estimates of both the moisture content and nutrient content, take several samples of the manure or compost and have them analyzed for moisture and nutrient content to get a more accurate estimate of the nutrients purchased and applied.

Some organic fertilizers contribute substantial amounts of organic matter, which often leads to increased water infiltration into the soil. Organic fertilizers may also improve the physical structure of the soil, which allows more air exchange with plant roots. Where organic sources are used for fertilizers, microbial activity usually increases in the soil, which may help make nutrients and water more available to plants. Because of the slow release of nutrients such as nitrate-nitrogen from the organic sources, alfalfa is a desirable crop because the deep roots take up the nitrates prior to being leached into groundwater. Manure and manure-based composts generally have higher phosphorus and potassium content than green wastes and other composts. The use of dairy and other lagoon waters as well as associated lagoon sludge should be evaluated with the organic certifier as to whether they meet organically approved guidelines.

Established Fields

In established alfalfa stands, plant tissue analyses are valuable tools to monitor the nutritional status of the plants in order to make decisions about fertilization needs. For information on how to take plant tissue samples and interpret the test results, see Chapter 6. Soil fertility and plant nutrient status can be maintained most effectively with animal manures, compost, green waste, and other approved organic fertilizers such as bone meal, guano, potassium sulfate, potassium magnesium sulfate and elemental sulfur. Rock phosphate, which can be used as both a liming material and a phosphorus source on acid soils (below pH 6.5), is quite expensive and usually not cost effective. Rock phosphate is almost completely ineffective on alkaline soils (pH greater than 7.0) because soil acidity must dissolve the material before the phosphorus becomes available for use by plants. The heavy metal concentrations of rock phosphate prohibit the use of this material originating from western United States sources.

Fertilizer application timing may be more important with organic alfalfa production than with conventional production due to the effect that organic fertilizer sources have on promoting weed growth. As a result, some variation in timing of organic fertilizer sources may be necessary depending on predominate weed species and the best time to fertilize alfalfa versus favoring competing weeds. Timing the application of manure or compost after the first or second cutting would give alfalfa the competitive edge to take up fertilizer nutrients rather than fertilizing the weeds providing that summer weeds are not problematic. Since many organic fertilizer sources contain nitrogen, applications during the winter months would be more likely to encourage late winter-spring weed growth prior to the onset of alfalfa growth. Making a second application during August or September when the alfalfa is growing vigorously would also serve to benefit alfalfa over weeds.

Insect Pest Management

Insects can be managed in organic alfalfa production using a variety of tools, including varietal resistance, cultural practices, conservation of natural enemies, and the use of approved organic insecticides (Table 21.2). The need for, and use of, all biological pesticides derived from natural sources is restricted and must be explained in the organic system plan. In addition, the organic system plan must justify that the use of cultural practices and preventive, mechanical, and physical methods are insufficient before organically approved pesticides will be allowed. Following is a discussion of organically approved methods for controlling major insect pests of alfalfa. See Chapter 9, "Managing Insects in Alfalfa," for more detailed descriptions of pest and natural enemy species, pest biology, how to sample, and economic thresholds, or refer to the UC Pest Management Guidelines http://ipm.ucdavis.edu.

Alfalfa Weevils

The Egyptian alfalfa weevil (*Hypera brunneipennis,* Boheman) and the alfalfa weevil (*H. postica,* Gyllenhal) are primarily first cutting pests of established alfalfa. They are considered to be the most serious alfalfa pests for organic growers because the larvae of these pests can severely defoliate stands causing yield and quality losses and there are few control options. Organic pesticides, such as Entrust® (spinosad), will give about 65 percent weevil control compared to conventional insecticides, but may not be economical depending on the weevil pressure. In addition, there are no resistant alfalfa varieties, and natural enemies are not efficacious enough to maintain weevil populations below damaging levels. Early cutting, before weevils reach peak numbers, will help control this pest, but yield of the first cutting will likely be reduced. In addition, larvae that survive the harvest process may concentrate under the windrow and cause extensive damage to alfalfa regrowth and possible stand loss.

Flaming with propane in late winter, just prior to when the alfalfa breaks dormancy, can reduce weevil populations by killing adults

as well as the eggs that are deposited in the stems. The charred alfalfa stubble may also be less attractive to adults returning to the alfalfa field to lay eggs during late winter. However, the level of control with propane depends on the weevil pressure and will not be as effective as the use of conventional insecticides. In addition, flaming may not be economically feasible given the high costs of fuel and should be weighed relative to the value of the alfalfa hay.

Winter grazing with sheep (See Chapter 17, "Alfalfa Utilization by Livestock") has also been shown to decrease the number of weevils and increase alfalfa yields (by consuming and trampling eggs and larvae that reside in the plant stems). However, for this option to be viable timing is critical and sheep are often difficult to obtain, so this practice may be limited. Grazing must occur when weevil eggs are hatching (January to March, depending on the field location) and the fields must be grazed to the ground. The sheep should also be managed carefully to prevent stand loss, especially under wet conditions. There is some suggestion that harrowing for winter weed control in established alfalfa stands may also provide some weevil control, but damage to the alfalfa crowns may occur making them more susceptible to diseases.

Overseeding alfalfa in the fall with grass or legume forages (which are not preferred by weevils) will increase spring yields and help compensate for losses caused by weevil damage to the alfalfa (see Chapter 15, "Managing

TABLE 21.2

Organically approved methods for controlling major insect pests in alfalfa in California[1]

Pest	Status[2]	Comments[3]
Egyptian Alfalfa Weevil		
Early harvest	A	Yield may be reduced.
Grazing or "sheeping off"	A	For maximum effectiveness, grazing must be timed at egg hatch (look for first signs of larvae and plant damage during winter). Animals must be managed carefully to prevent overgrazing and stand loss, especially under wet conditions.
Flaming with propane	A	Timing should occur at egg hatch. Degree of control depends on the severity of the weevil infestation and may not be economical.
Overseeding	A	Alters quality and possibly yield of harvested forage.
Entrust (spinosad) insecticide	R	May not be economical, depending on weevil pressure (65% average control compared with conventional insecticides).
Armyworms and Alfalfa Caterpillars		
Early harvest	A	Yield may be reduced.
Microbial insecticides	R	Most effective on smaller instars (XenTari, Agree).
Conservation of natural enemies	A	Border or strip harvesting.
Aphids		
Varietal resistance	A	See http://alfalfa.org for alfalfa varieties.
Conservation of natural enemies	A	Border or strip harvesting.
Early harvest	A	Yields may be impacted.
Pyrethrum, PyGanic, or Azadirachtin (Neem) insecticide	R	May not be economical.

[1]The need for and use of insecticides derived from natural sources should be explained in the organic system plan. The organic system plan must justify that the use of cultural practices and preventive, mechanical, and physical methods are insufficient before organically approved insecticides are allowed.

[2]Status designations: **Allowed (A)** include nonsynthetic materials that are not specifically prohibited by NOP rule Section 205.602 and synthetic materials that are specifically allowed by Section 205.601. **Restricted (R)** substances are allowed in organic production subject to NOP Rule use restrictions. **Prohibited (P)** substances in crop production are generally defined in NOP Rule Section 205.105.

[3]References are the USDA-NOP, 2003, Organic Materials Review Institute Generic Materials List, June 2004.

Depleted Alfalfa Stands"). However, this practice will change the forage quality and potential market and value of the alfalfa hay. Overseeding may also reduce the vigor of the alfalfa stand, so this practice should only be considered for weakened or older alfalfa stands that are in the final years of production.

Aphids

Most recently released alfalfa varieties have resistance to the pea aphid (*Acyrthosiphon pisum,* Harris), blue alfalfa aphid (*A. kondoi,* Shinji), and spotted alfalfa aphid (*Therioaphis maculata,* Buckton). Organic growers should choose varieties that have the highest level of resistance possible to help control these pests. A fourth aphid species, the cowpea aphid (*Aphis craccivora* Koch), is occasionally found infesting alfalfa, but host plant resistance is not yet available for this pest.

To manage aphids, one should preserve and enhance natural enemies such as ladybugs, lacewings, and parasitic wasps by border or strip cutting (see Chapter 9, "Managing Insects in Alfalfa") to leave habitat and some prey for the beneficial insects so they stay in the field. There is also a naturally occurring fungus that helps control some aphid species during warm, wet periods; however, it is not commercially available. Early harvest, as well as flaming, may help control aphids, but due to the high cost, flaming is not likely to be economically viable. The use of pyrethrum (PyGanic) or azadirachtin (Neemix, Agroneem, or Trilogy) may help control aphids in alfalfa if outbreaks occur, but the degree of control with these materials may not be economical and should be weighed relative to the value of the alfalfa hay.

Caterpillars

The beet armyworm (*Spodoptera exigua,* Hubner), western yellow striped armyworm (*S. praefica* Grote), and the alfalfa caterpillar (*Colias eurytheme* Boisduval) are major pests of alfalfa with outbreaks usually occurring in July and August. Early cutting, before significant damage occurs to the alfalfa, will help manage these pests. Most larvae that survive the cutting process are killed by the hot dry conditions or preyed upon by birds following harvest so will not damage alfalfa regrowth under the windrows. However, the larger armyworm larvae can migrate to surrounding crops so it may be advisable to plow a ditch between the alfalfa and the adjacent crop and fill it with water to keep them from moving beyond the field. Conservation and enhancement of naturally occurring beneficial insects will also help provide biological control of caterpillar pests. This can be done through strip or border cutting to help retain the beneficial insects in the field as described in Chapter 9. The alfalfa caterpillar, beet armyworm, and western yellow striped armyworms can also be controlled with the microbial insecticides XenTari or Agree *(Bacillus thuringiensis* subsp. *aizawai)* when the insects are in the small larval stages.

Weed Management

Strategies for managing weeds in seedling and established organic alfalfa without herbicides involve a combination of practices including good seedbed preparation, selective grazing, harrowing, flaming with liquid propane, adjusting irrigation and cutting schedules, and overseeding with alternative forages (Table 21.3). For more detailed information on all weed control practices in alfalfa, see Chapter 8, "Weed Management in Alfalfa."

Seedling Fields

Establishing vigorous alfalfa fields is critical for weed management throughout the life of the stand because strong stands help outcompete weeds. Prior to planting, prepare a good seedbed, preferably on well-drained soils, to ensure good seed germination and prevent plant dieback as a result of standing water. Planting alfalfa in rows on beds or on shallow corrugations is commonly practiced in areas where soils lack sufficient drainage. However, some organic growers have found increased weed problems in furrows.

Planting should occur in the fall (September–October) when conditions favor stand establishment. Alfalfa fields planted during winter (December) will grow too slowly,

TABLE 21.3

Organically approved methods for weed control in alfalfa in California

Stage of stand	Status[1]	Comments
Seedling fields		
Time of seeding	A	Seed early fall when summer weeds are not as competitive and before winter weeds germinate for optimum alfalfa vigor.
Early harvest	A	Yield and stand may be impacted, especially under high weed densities.
Grazing or "sheeping off"	A	Must manage sheep carefully to prevent soil compaction and stand loss, especially under wet conditions. Perennial and/or grass weeds less affected.
Interplanting oats with alfalfa	A	Generally lowers nutritional value of harvested forage for the first and second cutting.
Established fields		
Grazing or "sheeping off"	A	Must manage sheep carefully to prevent soil compaction and stand loss, especially under wet conditions.
Flaming with propane	A	Best used for spot treatment of weed-infested areas (such as dodder) due to the high fuel costs.
Adjust irrigation and cutting schedules	A	Most useful for management of summer weeds. Effectiveness depends on soil type and weed pressure.
Overseeding	A	Changes quality of harvested forage.
Tillage	A	Practice occurs when alfalfa is dormant. May injure alfalfa crowns leading to plant disease.

[1]Status designations: **Allowed (A)** include nonsynthetic materials that are not specifically prohibited by NOP Rule Section 205.602 and synthetic materials that are specifically allowed by Section 205.601. **Restricted (R)** substances are allowed in organic production subject to NOP rule use restrictions. **Prohibited (P)** substances in crop production are generally defined in NOP Rule Section 205.105.

allowing winter weeds to take over while those planted late spring will likely be overrun by summer weeds. Fall plantings are especially important for fields infested with field bindweed (*Convolvulus arvensis* L.), perennial grasses, or nutsedge (*Cyperus* spp.) to ensure that the alfalfa becomes well established to help outcompete these weeds when they start growing in the spring. If possible, a more nondormant variety should be selected to ensure fast regrowth following harvests to further help with weed suppression. Prior to planting, the fields should be irrigated to germinate weeds followed by tillage with a spring-toothed harrow and ring-roller for weed control and seedbed preparation.

Interplanting oats (*Avena sativa* L.) with the alfalfa during stand establishment can suppress weeds without the use of herbicides, and the oats also help reduce soil erosion. The oats should be planted at the same time as the alfalfa at a seeding rate of 15–20 pounds per acre (17–22 kg per hectare). The first several cuttings will be a mixture of oats and alfalfa, which will affect the marketability of the hay (dairy versus other feed). However, losses in quality should be offset by higher yields, and by the third cutting pure alfalfa will be harvested. There should be minimal impact on alfalfa stand density. Curing time for the first cutting will be several days longer than for alfalfa alone.

If weeds become established in seedling stands, fields should be cut close to the ground in the spring to help inhibit weed growth. This will allow the alfalfa to regrow and compete more successfully against existing weeds. In the Low Desert, sheep grazing is sometimes used to remove winter annual weeds in new plantings. Harvest management practices should be followed as outlined in Chapter 13, "Harvest Strategies for Alfalfa," to prevent stand injury caused by cutting or grazing too early or under wet conditions.

Established Fields

Grazing or "sheeping off" during the winter can provide good weed control in established fields (Fig. 21.2), but the sheep must be managed carefully to prevent stand loss, especially under wet conditions. Harrowing also provides some winter weed control, but may cause some stand loss from uprooting and injury of the alfalfa crowns. Flaming can provide some control of seedling weeds, including dodder (*Cuscuta* spp. L), but given the high cost of fuel this practice is best suited for spot treatments of weed-infested areas.

Adjusting irrigation and cutting schedules can also inhibit weeds and enhance stand life. Irrigating alfalfa as close to harvest as possible will allow the alfalfa to regrow more quickly after cutting. Shading will help the alfalfa compete against seedling weeds. Dry soil after harvest also minimizes weed seed germination when the canopy is open. A shorter cutting interval improves forage quality, but reduces alfalfa vigor and encourages weed growth. As a result, alfalfa stands should be properly managed to take into account the tradeoff between time of cutting, yield, forage quality, and stand life.

Overseeding alfalfa stands with annual or perennial grasses or legumes will also help suppress weeds (Fig. 21.3), but is only recommended for weakened or older stands that are in their final years of production. Typically overseeding occurs in the fall after harrowing alfalfa fields to prepare a seedbed and the forage is seeded directly into the stand. Yields are enhanced for spring cuttings, but the forage is mixed, affecting forage quality and markets. For more information on this practice, see Chapter 15, "Managing Depleted Alfalfa Stands."

Disease Management

There are many diseases that cause yield, quality, and stand losses in alfalfa as described in Chapter 10, "Alfalfa Diseases and Management." This chapter focuses on the most significant alfalfa diseases with an emphasis on the use of resistant plant varieties and cultural practices to maintain healthy alfalfa stands. Plant resistant variety information can be found in Chapter 5, "Choosing an Alfalfa Variety," and through the National Alfalfa Alliance, http://alfalfa.org.

FIGURE 21.2

Grazing with sheep can be used to manage weeds in alfalfa stands.

FIGURE 21.3

Interseeding or overseeding oats in alfalfa can be used to help manage insects and weeds, and increase productivity of aging stands.

The major diseases that can affect alfalfa stand establishment include the soilborne fungi *Rhizoctonia spp., Pythium spp.,* and *Phytophthora spp.,* that may cause dieback of seedlings before or soon after they emerge. These diseases are favored by poor growing conditions including too much water, compacted or poorly drained soils, and temperatures unfavorable for alfalfa germination and growth. To manage these diseases, alfalfa should be planted during early fall when conditions are most favorable for alfalfa growth. On heavier soils where waterlogging may occur, growers should consider planting alfalfa on beds to help with drainage. However, this strategy must be balanced by increased weed pressure that may occur in the furrows due to the lack of competition from established alfalfa plants.

One of the major soilborne diseases of established alfalfa is root and crown rot caused by *Phytophthora spp.* Saturated soils are required for this disease, so proper soil preparation (eliminating low spots) and good irrigation management can reduce the opportunity for this fungus to infect roots. Select plant varieties that are resistant to phytophthora, which come in many different dormancy classes. For heavy soils with a potential to waterlog, consider selecting a more dormant variety that begins to grow later in the season when soils dry as alfalfa is most sensitive to root rot when it is actively growing in wet conditions. However, this strategy should be balanced with a reduction in yield associated with more dormant varieties, though hay quality may improve. Growers should also be careful not to stress fields by over or under irrigating or cutting fields too frequently as stressed plants will be more susceptible to diseases.

Other root and crown diseases such as anthracnose and stagonospora can reduce stands. Cultivars resistant to anthracnose are listed in the National Alfalfa Alliance publication. For these diseases, and also many of the foliar diseases such as common leaf spot, spring blackstem, and downy mildew and bacterial caused diseases, crop rotation is helpful in reducing disease pressure. The pathogens causing these diseases survive in alfalfa stems, old leaves and rotting crowns. Rotating out of alfalfa for a minimum of 2 years should reduce the inoculum in the field and delay infection of new plants. Another strategy is to cut and bale younger fields before older ones to reduce the introduction of infected alfalfa debris into the new fields when harvesting. Within reason, when moving from old to new fields, blow out any leaves or stems that are in or on harvest equipment. If leaf spots become widespread, early harvest can minimize defoliation due to the loss of infected leaves.

Sclerotinia stem and crown rot, which is a problem during wet winters, can be managed in established fields by taking a late fall cutting so that there is relatively little canopy during December and January when this disease is most likely to occur. For seedling fields, plantings in February or March will usually avoid this disease but the advantages of a fall planting (quick emergence, less weed competition, higher yields the first year) are lost.

Nematode Management

Plant parasitic nematodes are microscopic roundworms that live in the soil and feed either on or in alfalfa plants, causing extensive chronic yield and quality losses. Although there are many types of nematodes affecting alfalfa production, this chapter focuses on organic management practices for the major root-knot and stem nematodes found in California. For more detailed information on nematodes, including sampling and identification of species, see Chapter 11 on "Parasitic Nematodes in Alfalfa."

Alfalfa roots infected with the root-knot nematode *(Meloidogyne spp.)* have numerous firm galls and may branch excessively. Stem nematodes (*Ditylenchus dispsaci,* Kuhn) cause plants to have shortened, stunted and chlorotic stems with swollen nodes (where leaves attach to stems) and short internodes. The key approach to managing these nematodes is to use resistant plant varieties, which are available in many different dormancy types (refer to the National Alfalfa Alliance at http://alfalfa.org). Be sure to know the nematode species infecting the field because varietal resistance to one nematode species does not necessarily mean

the alfalfa will be resistant to another species. For stem nematode control, use certified seed to minimize the chance of contaminating previously uninfested land.

When selecting a site to plant organic alfalfa, select fields that are not infested with nematodes known to be pathogenic to alfalfa. It is also important to wash farm equipment with water to remove soil and plant debris when moving between fields. Avoid using irrigation runoff water from known nematode infested fields to irrigate uncontaminated fields. Delaying cutting until the top 2 to 3 inches of soil is dry will minimize the spread of stem nematode.

For stem nematode control, a 3- to 4-year crop rotation with small grains, cotton, beans, corn, lettuce, melons, carrots, or tomatoes will help control this pest in alfalfa. However, root-knot nematodes have a wide host range in both crops and weeds, so crop rotation is usually not feasible for managing this nematode. The addition of soil amendments prior to planting, including cover crops or composted plant and animal materials, may also help manage nematodes. Such benefits may include improved soil and plant health (reducing nematode stress), enhanced microbial activity including nematode-feeding organisms, and the production of nematode-killing compounds from certain plant breakdown products (such as rapeseed). However, the efficacy of soil amendments on actual nematode mortality and corresponding plant yield is still not well known.

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Vertebrate Pest Management

Pocket gophers (*Thomomys* spp.), voles or meadow mice (*Microtus* spp.), and ground squirrels (*Spermophilus* spp.) can be significant pests of alfalfa. Feeding damage, both above and below ground by these rodents, can significantly weaken and often kill alfalfa plants, resulting in yield, forage quality, and stand losses. In addition, the gopher and squirrel burrows and tunnels can cause damage to harvest equipment and disrupt irrigation flows. Since there are no rodenticides available for use in organic alfalfa production, management practices primarily focus on cultural and mechanical practices for rodent control. For more detailed information on the biology of gophers, squirrels, and voles as well as other vertebrate pests found in alfalfa, see Chapter 12, "Integrated Management of Vertebrate Pests in Alfalfa."

If there were problems with rodents in previous crops, consider rotating with cereal crops (barley, wheat, oats, ryegrass, or sudangrass), which may reduce gopher activity. Prior to planting alfalfa, check the field and the surrounding landscape to determine possible sources of vertebrate pests. Remove unmanaged cover along fencerows, roadsides, and ditch banks where rodents often hide and build up to prevent them from dispersing into new alfalfa fields. During ground preparation, deep tillage can be used to disrupt or destroy ground squirrel burrows prior to planting alfalfa. However, gophers can survive cultivation and deep tillage, so they should be trapped where activity is observed prior to planting.

In established alfalfa, flood irrigation nearly eliminates ground squirrels (except perhaps on field edges) and can significantly decrease gopher numbers, possibly reducing the potential for large populations to rebuild. Reducing the amount of vegetative cover during the winter months by mowing and sheep grazing will aid in reducing voles. Shooting, trapping, and the use of owl boxes and perches to attract raptors, as well as encouraging other birds such as egrets and herons to forage in alfalfa, may also help improve the control of rodents.

Additional Reading

Canevari, W.M., D.H. Putnam, W.T. Lanini, *R.F. Long, S.B. Orloff, B.A. Reed, R.N. Vargas.* 2000. Overseeding and companion cropping in alfalfa. University of California Division of Agriculture and Natural Resources, Oakland. Publication 21594.

CDFA-OP. California Department of Food and Agriculture, California Organic Program, http://www.cdfa.ca.gov/is/i_&_c/organic.html.

Long, R., S. Orloff, R. Meyer. 2007. Sample costs to produce organic alfalfa hay in California. University of California Cooperative Extension. http://coststudies.ucdavis.edu.

National Alfalfa Alliance. http://alfalfa.org.

OMRI. Organic Materials Review Institute, http://www.omri.org.

UC IPM. University of California integrated pest management guidelines for alfalfa. http://www.ipm.ucdavis.edu/PMG/selectnewpest.alfalfa-hay.html.

USDA. U.S. Department of Agriculture National Organic Program (NOP) regulations. http://www.ams.usda.gov/nop/.

WSDA. Washington State Department of Agriculture organic materials lists and material registration. http://agr.wa.gov/FoodAnimal/Organic/MaterialsLists.htm.

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An electronic version of this publication is available on the ANR Communication Services Web site at http://anrcatalog.ucdavis.edu.

Publication 8307
ISBN-13: 978-1-60107-551-2

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

6/08-WFS