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Organic Alfalfa Production

Agronomic Production Guide

Abstract: Demands for organic dairy feed are on the rise due to passage of the National Organic Program's (NOP) organic standards in 2001. Cows producing organic milk must be fed organic hay. This publication discusses basic cultural requirements, insect pest management, diseases of alfalfa that include root and crown diseases and foliar diseases, nematodes, vertebrate pests, weed controls, and economics and marketing. Included are references and resources.

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Table of Contents

Introduction

The rise in demand for organic dairy feed makes alfalfa an attractive crop for some organic farmers. According to the USDA's organic standards, cows producing organic milk must be fed organic feed. The decision to grow organic alfalfa depends on the potential profitability, taking into account price premium, increased cost of production, markets, and transportation. Federal laws regulating the growing, labeling, and marketing of organic products require producers to be certified through a private or state agency. ATTRA has several publications on the topics of organic certification and production. *Organic Farm Certification & The National Organic Program* addresses the new federal requirements.

An Overview of Organic Crop Production provides a general introduction to organic farming methods and would be considered a prerequisite to starting an organic alfalfa enterprise. The *Organic and Sustainable Practices Workbook and Resource Guide for Cropping Systems* is recommended especially for producers new to organic farming. These and other relevant ATTRA publications are available in print and on our Web site http://www.attra.ncat.org.

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NCAT

Basic Cultural Requirements

From an agronomic perspective, alfalfa is a great rotational crop because of its soil conditioning abilities. In addition, the perennial nature of alfalfa creates a favorable habitat for many beneficial arthropods, including pollinators and natural enemies of pests. These natural enemies help keep pest levels down in alfalfa and adjacent crops.

The basic cultural requirements for alfalfa are similar whether it is grown organically or conventionally. Seeding rates typically range from 12 to 15 pounds per acre. Seed may be drilled or broadcast into a well-prepared seedbed. Firm seed-to-soil contact is necessary and may be achieved with a cultipacker or from the drill presswheels. If the seedling stand in the tractor tire tracks is better than the rest of the field, that is a sign the seedbed needs to be firmer. If your shoes sink into the prepared soil past the soles, that too shows the need for a firmer seedbed. Plant high quality seed that is inoculated with the appropriate rhizobium bacteria strain to assure good nodulation and nitrogen fixation. Select a variety that is well adapted to your area and the diseases common there. Detailed production information on alfalfa growing practices (soil pH, planting dates, seeding rates, and varieties for specific areas) can be obtained from your local Cooperative Extension Service.

Alfalfa requires a deep, well-drained, loamy soil with a pH between 6.5 and 7.5, free of hardpans and shallow bedrock, to accommodate the plant's long taproot that can penetrate to 20 feet. Alfalfa responds well to phosphorus and potassium fertility, but no nitrogen is required, since alfalfa (being a legume) fixes its own nitrogen. It also uses three to five pounds of boron per acre per year. Adequate lime, phosphorus, and potassium levels should be established prior to planting, if possible. Base fertilizer application rates on soil-test results, crop needs, and the nutrient content of the material being applied. After the crop is established, only surface applications will be possible. Wet soils can cause root heaving during winter and cause more problems with root diseases than well-drained soils.

In an organic system, soil fertility can be maintained with mineral–bearing rock powders such as rock phosphate and with animal manures, compost, and other natural fertilizers. Two useful potassium sources are potassium sulfate and potassium magnesium sulfate. Potassium sulfate must be mined and non-synthetic. OMRI (Organic Materials Review Institute, Box 11558, Eugene, OR 97440-3758, http://www.omri.org) evaluates commercial products for organic production. Accepted brand names are Ag Granular, Ogden Sulfate of Potash, Turf Blend™ Green Grade, Turf Blend™ Mini Granular & Turf Granular, all from Great Salt Lake Minerals; Standard Sulfate of Potash & Water Soluble Sulphate of Potash (SQM North America Corp.), and Ultra Fines Sulfate of Potash (Diamond K Gypsum). K-Mag's (K-Mag Granular Natural® Crystals™ & K-Mag Standard) generic material is langbeinite, and it is OMRI listed. Mined elemental sulfur and borax can also be used.

Granite dust and greensand are potassium-containing minerals used by some organic farmers that release available potassium very slowly. They are not cost-effective for large acreages unless mined locally. For additional fertility information, request the ATTRA publications *Sustainable Soil Management*, *Alternative Soil Amendments*, and *Manures for Organic Crop Production*. Animal manure can provide both phosphorus and potassium economically. It is beneficial to base manure and compost rates on soil test nutrient levels, the nutrient content of the manure, and crop needs.

Harold Willis's book *How to Grow Great Alfalfa* (Willis, 1983) provides a nice overview of reduced-input alfalfa production that is largely applicable to organic management. Willis covers the basics and goes a step further to discuss the relationships among soil biology, alternative forage-testing methods, and alternative pest management for alfalfa.

Insect Pest Management

Insect pest management in an organic system depends on several factors—including climate, beneficial organisms already present in the area, and hay-cutting schemes. Many types of insects and mites inhabit alfalfa plantings, yet only a few species threaten yields. Proper identification of alfalfa pests as well as their natural enemies is the first step in successful manage-

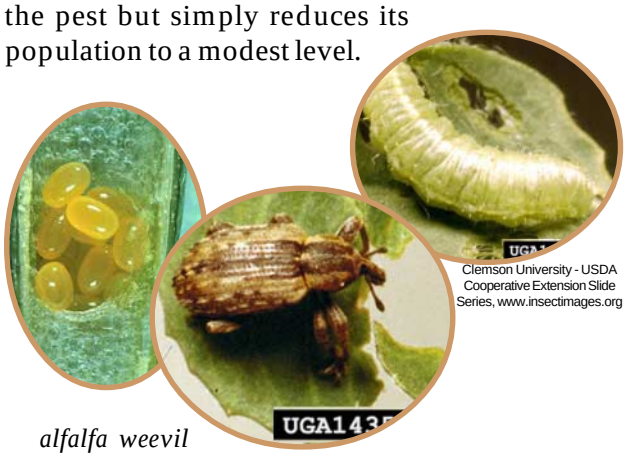
ment of pests. Some local Extension service specialists are familiar with pests common to specific areas and can help with proper identification. State Extension services along with their universities have Internet-based information that can aid with pest and beneficial insect identification. Once this information is known, a scouting program with regular monitoring can help the grower determine the pest pressures and the presence of beneficial insects. When pest pressures reach the economic threshold, control actions are necessary. That is why monitoring is so important. For more information on sustainable pest control, see the ATTRA publication *Biointensive Integrated Pest Management*.

Table 1. Alfalfa Pests and Their Predators

Alfalfa Pest / Predators	Big Eyed Bug	Damsel Bug	Assassin Bug	Lacewing Larva	Ladybeetle	Spiders	Minute Pirate Bug	Parasitic Wasps
Alfalfa Weevil	X	X	X	X	X	X		X
Caterpillars	X	X	X	X		X	X	X
Aphids	X	X		X	X		X	X
Alfalfa Hopper	X	X						
Whiteflies	X			X	X		X	X
Potato Leafhopper								

Alfalfa weevils

Alfalfa possesses several characteristics that favor biological weevil control. First, it is a perennial plant grown primarily for forage, with individual stands persisting for three to seven years. This stable system helps populations of beneficial organisms increase. Secondly, although protein content of alfalfa hay is important, cosmetics are not as important as for fresh vegetable and fruit crops. Because alfalfa can tolerate some damage, it is an ideal crop for a pest management system that does not completely eliminate the pest but simply reduces its population to a modest level.



alfalfa weevil

Spring weather conditions influence the severity of alfalfa weevil damage. During a prolonged cold spring, weevil larvae do not grow as fast as the alfalfa. In this situation the plant matures before weevils can severely damage it. During a warm spring, or in warmer areas of the country, larval populations will increase faster than plant growth, resulting in extensive plant damage (Metcalf and Luckmann, 1982).

Some farmers find that healthier alfalfa stands are less likely to be damaged by weevils. Some even use refractometers to monitor stand health. The refractometer is an instrument that provides a measurement of the soluble solids or sugar in a plant. A high refractometer reading reflects a high plant sugar level. As sugar levels increase, plants are better able to resist pest insects (Behling, 1992).

According to Bowman (1992), a mixed planting of alfalfa and grasses can reduce weevil and leafhopper levels in some areas. Harvesting alfalfa in alternate strips has also been shown to dramatically increase the number of beneficial insects occurring in the field (Anon., 1993). Rather than having all of their habitat stripped away from a whole-field harvest, the beneficials from the cut strips can move onto the neighboring remaining strip and continue to find food and shelter. Generalist predators like spiders, damsel bugs, bigeyed bugs, assassin bugs, and lacewing larvae attack alfalfa weevil larvae. Adult and larval aphid-eating lady beetles have been observed feeding on alfalfa weevil larvae (Kalaskar and Evans, 2001).

Grazing the spring growth of alfalfa in the late vegetative and early bud stage allows for nearly all the weevil larvae to be consumed by the livestock before economic damage occurs (Gerrish, 1997). In a four-year conventional al-

falfa study done in Oklahoma (Anon. 1999), researchers achieved such good weevil and aphid control from grazing that only one insecticide application was necessary throughout the whole study period. Grazing also aided the control of cool-season weeds.

Some producers use "flaming" to complement their weevil-management program. Field flamers that burn LP gas are pulled across the field after harvest. The flames are directed at the ground to burn off the weevils and their eggs. In a Kansas study, alfalfa fields were flamed in early spring. Flaming reduced the weevil larvae from 2.2 to 0.3 per stem in the first year of the study, and from 2.7 to 0.9 during the second year of the study (Anon., 1993). There were no yield or quality differences between flaming or several insecticides treatments that were compared. In addition to weevil control, flaming alfalfa can reduce weed levels. Early spring flaming controlled 75% of Tansy mustard and shepherds purse and 46% of Kentucky bluegrass at a rate of 22 gallons of propane per acre in a California study (Behling, 2002). In the same study, 11 gallons per acre controlled 50% of the weeds. Flame Engineering (see **References** for contact information) in LaCrosse, Kansas, has tractor mounted equipment and literature to support this practice.

Taking a last cutting of alfalfa as late in the season as possible may reduce alfalfa weevil damage to the next year's crop (Metcalf and Luckmann, 1982). With most of the foliage gone, the field is less attractive to adult weevils seeking a place to lay their eggs during the fall. Late cuttings may reduce winter hardiness, however, due to lack of vegetation to trap and hold snow that insulates the alfalfa crowns and prevents them from freezing. The root reserves can be depleted if the alfalfa is cut too late in the season. After the last cutting, the foliage should grow some to allow the roots to store food before the first killing frost. Another method is to graze off the fall top-growth well after freezing weather has set the plants into dormancy, reducing weevil egg numbers for next year. Grazing the early spring growth before significant weevil damage occurs uses the forage directly and reduces the need for additional control measures. To best employ this practice, select alfalfa varieties that are adapted for grazing and practice rotational grazing or strip grazing.

It is important to remember that adult weevils do not overwinter only in alfalfa fields. They also live in areas adjacent to these fields. In areas where fall or winter egg-laying does not occur, growers will have to deal with spring adult weevil migration into the field, and subsequent egg-laying.

Classical biocontrol efforts for alfalfa weevil in the U.S. have emphasized the introduction of effective parasites into areas where these natural control agents are rare or absent (Yeargan, 1985). During the 1980s, the USDA Animal and Plant Health Inspection Service (APHIS) and its cooperating agencies led the effort to establish alfalfa weevil parasites. In 1991, APHIS completed its ten-year parasite release program.

In the long run, a large population of beneficials can help provide permanent control of weevil pests. However, newly introduced biocontrol agents often take at least three years to bring their prey under control. Farm managers should therefore try to conserve and foster existing populations of beneficials. Another ATTRA publication that discusses how to conserve beneficials, *Farmscaping to Enhance Biological Control*, is available on request.

The larval parasites *Bathyplectes anurus*, *Bathyplectes curculionis*, and *Oomyzus (Tetrastichus) incertus*, and the adult weevil parasites *Microctonus aethiopoides* and *Microctonus colesi*, in addition to the insect eating fungus *Zoophthora phytonomi*, are effective natural enemies of the alfalfa weevil in the eastern U.S. The western U.S. is less favorable to these organisms for biological control of the alfalfa weevil, except for *Bathyplectes curculionis*, which is very effective in many areas of the West (Flint and Dreistadt, 1998). In northern Utah, research trials were conducted where a sugar solution was sprayed onto the alfalfa foliage in order to increase the numbers of the alfalfa weevil parasite *Bathyplectes curculionis*. When sampled two days later, numbers of adult parasitoids were consistently higher in the sugar plots than in the control plots (Jacob and Evans, 1998). If aphid or whitefly honeydew is present in a field, sugar sprays to attract the parasites may be redundant. Honeydew can also bring on sooty mold fungus that can reduce hay quality. Records from the eastern U.S. indicate that where nine out of ten alfalfa fields were sprayed for weevils ten years ago, only one in ten is sprayed now (Yeargan, 1985). Pest management experts attribute this dramatic decrease in weevil spraying to the release of beneficial parasites. The alfalfa weevil egg predator *Peridesmia discus* was

introduced from Europe as a biological control agent. It is now known to be established in parts of Georgia, Maryland, North Carolina, South Carolina, and Tennessee. Data from some of these sites indicate that from 5.6 to 16.7% (7.1 average) of overwintering weevil eggs were preyed on by *P. discus* (Dysart, 1988).

A number of "natural" pesticides may be used in organic production. Of the botanical insecticides, neem has been proven effective against the alfalfa weevil by acting as a toxicant, insect growth regulator, and antifeedant. In caged tests under field conditions, 2.5 and 5% Neem seed suspensions applied four times at weekly intervals to naturally infested alfalfa completely interrupted the larval development of the pest and increased yields. (Oroumchi and Lorra, 1993).

Caterpillar Pests

Caterpillars have many natural enemies that usually keep their numbers below damaging levels. Understanding the biology of beneficial organisms is important in order to manage them effectively as pest-control agents. For example, insect parasitic nematodes like *Steinerema carpocapsae* or insect infecting fungi like *Beauveria bassiana* require adequate humidity to be effective. Other predators include spiders, minute pirate bugs, damsel bugs, bigeyed bugs, assassin bugs, lacewing larvae, and parasitic wasps. Birds also prey on caterpillars, so do not assume that all birds in the field are causing damage.

Bacillus thuringiensis is an effective biorational pesticide that controls caterpillar pests. Early detection and application during the early developmental stages of the larvae (1st and 2nd instar) make these pesticides more effective. Pheromone traps are useful tools that indicate when mating flights are occurring. Through degree-day calculations from mating time, one can estimate egg laying and hatching. For information on degree-day calculations contact your local county Extension agent. Pheromone lures and dispensers are becoming popular for mating disruption of some caterpillar pests. These must be deployed and timed with the insects' mating flights in order to cause confusion and interrupt potential mating.

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alfalfa caterpiller butterfly

The alfalfa butterfly (*Colias eurytheme)* or Orange Sulphur, as it is commonly known, is found throughout the country and is considered a pest on alfalfa only when the climate is warm and the presence of natural enemies is low. The adults have yellowish or whitish wings with dark borders. The larvae are velvety green with white lines on their sides. The larger larvae (1½ inches) causes the most damage by consuming the entire leaf and defoliating the crop. The natural enemies that prey on or parasitize the alfalfa caterpillar include the predators mentioned above, the larval parasitic wasp *Cotesia medicaginis,* and the egg parasite *Trichogramma semifumantum.*

green lacewing larvae

bigeyed bug adult

bigeyed bug nymph

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Cutworms are a problem in seedling establishment in some alfalfa-growing areas but rarely a problem on established stands. Species are represented by the variegated cutworm, *Peridroma saucia*; black cutworm, *Agrotis ipsilon*; granulate cutworm, *Feltia subterranea*; army cutworm, *Euxoa auxiliaris;* and the Clover cutworm, *Scotogramma trifolii.* They are active at night, feeding and chewing through the stems of the seedlings. In the day they burrow underground or under clods, avoiding detection. Problem areas are usually found near field borders and in weedier areas. Cutworms have many predators and parasites that help control their numbers. Some of these parasites and predators can be purchased or harnessed naturally through planting or conserving habitat for them.

granulate cutworm

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If organically-acceptable pesticide applications are necessary, choose one that is least disruptive to the natural enemies. The application of rolled oats and molasses baited with *Bacillus thuringiensis* or nighttime spraying of *Bacillus thuringiensis* are effective strategies.

Other alternative controls for cutworm include the use of thyme's essential oils as a toxicant, insect growth regulator, and antifeedant (Hummelbrunner and Isman, 2001). Mock Lime or Chinese Rice Flower Bush, *Aglaia odorata*, inhibits larval growth and is insecticidal to cutworms *Peridroma saucia* and *Spodoptera litura*, but no commercial formulations are currently available (Janprasert et al., 1993). Azadirachtin, the active ingredient in neem, also has similar effects on various insects and is used in the form of neem cakes to control soil pests in India. Certis USA produces Neemix® Botanical Insecticide; it's active ingredient is Azadirachtin and is registered on alfalfa for cutworm, looper, armyworms, whitefly, and aphids.

Beet armyworm, *Spodoptera exigua*, and fall armyworm, *Spodoptera frugiperda*, can both feed on alfalfa and on rare occasions cause yield reductions. Beet armyworms can cause yield reductions in alfalfa if populations are high enough. Armyworms hatch in clusters, and the small worms spread through the plants over time. They cut irregular shapes on leaves, skeletonizing them, trailing frass, and spinning small webs as they go. The egg clusters are covered with white cottony webbing, making them easy to spot. Both the removal of natural enemies and warm weather conditions are favorable to outbreaks.

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beet armyworm adult

beet armyworm larvae

Natural enemies are assassin bugs, damsel bugs, bigeyed bugs, lacewing larvae, spiders, the parasitic flies *Archytas apicifer* and *Lespesia archippivora*, and the parasitic wasps *Trichogramma ssp. Hyposoter exiguae, Chelonus insularis,* and *Cotesia marginiventris.* Nuclear polyhedrosis virus is a disease-producing virus that infects beet armyworm. It is available in the product Spod-X® LC (Certis). *Bacillus thruingiensis* on young worms is effective if application is thorough. Laboratory and greenhouse tests showed that caffeine boosted the effectiveness of the B.t. against armyworms up to 900 percent (Morris, 1995). Like B.t., caffeine interferes with the pests' digestive and nervous systems. Its use is most promising against pests that are weakly susceptible to B.t. itself. Recipe: dissolve 13 oz. pure caffeine in water; add the solution to 100 gallons of standard B.t. spray; apply as usual. (Morris, 1995). Caffeine can be obtained from most chemical supply houses and is also available in pill form from most pharmacies. Organic growers interested in this approach should ask their certifying agency about the appropriateness of this treatment in a certified organic system.

Many other crops are hosts to armyworms, as are the weeds mullen, purslane, Russian thistle, crabgrass, Johnson grass, morning glory, lambsquarters, nettleleaf goosefoot, and pigweed. These last three are preferred hosts that can serve as indicators of the populations or be managed as trap crops.

Alfalfa looper adult

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Alfalfa looper larvae

The Alfalfa looper, *Autographa californica*, and the Cabbage looper, *Trichoplusia ni*, feed on leaf areas between veins, causing ragged-edged holes in the leaf and on the leaf margins, but they rarely cause significant damage because of their natural enemies. If the enemies are lacking, defoliation of alfalfa may become severe.

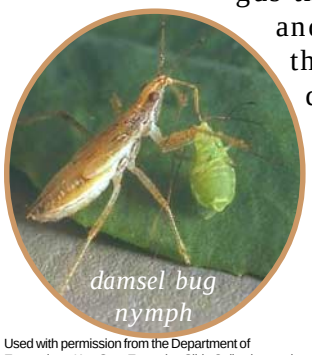
Loopers feed on all the crucifers, crops and weeds, and on melons, celery, cucumbers, beans, lettuce, peas, peppers, potatoes, spinach, squash, sweet potatoes, and tomatoes. Other hosts include some flowers, like stocks, snapdragons, and tobacco. Some weed hosts include lambsquarter, dandelion, and curly dock.

In addition to the natural enemies mentioned above, many parasitic wasps also attack loopers,

including *Trichogramma pretiosum*, *Hyposoter exiguae*, *Copidosoma truncatellum*, and *Microplitis brassicae*. The parasitic fly *Voria ruralis* also contributes to the loopers' natural control. *Trichoplusia ni* NPV (nuclear polyhedrosis virus) is sometimes responsible for sudden decline in looper population, especially after a rainfall. *Bacillus thruingiensis* is effective when the problem is detected early.

Aphids

Aphids are piercing and sucking insects from the order Hemiptera that feed on alfalfa, resulting in stunting, leaf curling or distortion, leaf drop, and yellowing of the plant. They excrete honeydew, which is a food for sooty mold fungus that contaminates alfalfa and lowers its quality. On the positive side, honeydew can serve as a food source for beneficial insects. The principal aphids that attack alfalfa are Pea aphids, *Acyrthosiphon pisum*; Blue alfalfa aphids, *Acyrthosiphon kondoi*; Spotted alfalfa aphids, *Therioaphis maculata*; Alfalfa aphids, *Macrosiphum creelii*; Clover aphid, *Nearctaphis bakeri*; Cowpea aphid, *Aphis craccivora*; Green peach aphid, *Myzus persicae*; and the Potato aphid *Macrosiphum euphorbiae*. Aphids have many natural enemies that usually keep their numbers down. These include syrphid flies, aphid flies, bugs (minute pirate bugs, damsel bugs, bigeyed bugs), lady beetles, soldier beetles, lacewing larvae, insect eating fungi, and several parasitic wasps.



damsel bug nymph

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lady beetle adult

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Potato Leafhopper

The potato leafhopper is a serious pest of alfalfa in the eastern U.S. Like aphids, they pierce stems and suck plant juices, disrupting plant functions. The symptoms are stunting and yellowing of the crop, but once the symptoms are visible, the damage to the crop is done. Scouting is critical to prevent this from happening. The adult leafhoppers are about 1/8 inch long, green insects with wings that when at rest resemble pup tents. Immature leafhoppers are called nymphs and look like wingless adults. Both the adult and nymph feed on plants.

potato leafhopper

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Planting grasses in the alfalfa stand is a cultural practice that reduces leafhopper damage. Grass repels leafhoppers, and the females are less likely to lay eggs in mixed stands. A Missouri study (Bowman, 1992) showed leafhopper reductions of 54 to 76% over a three-year period in a grass-alfalfa mixture as compared to pure alfalfa stands. The University of Minnesota Extension has a chart that compares alfalfa height to number of leafhoppers per sweep to aid in determining when to take action to prevent economic injury. The Web site is: http://www.extension.umn.edu/distribution/cropsystems/DC3516.html#plh.

Three cornered Alfalfa Hopper

The three cornered Alfalfa Hopper, *Spissistilus festinus*, is a major pest in the South. It is another piercing and sucking, triangular green insect that feeds on alfalfa stems and leaves. It is also found on vegetables, soybeans, peanuts, other legumes, grasses, small grains, sunflower, tomatoes and weeds. On alfalfa, it girdles the stem during feeding, causing it to become brittle and fall over. Natural enemies include the bigeyed bug and damsel bug. The bigeyed bug has been observed causing the highest mortality (90-100%) of 1st and 2nd nymphal stages, while the damsel bug attacked all nymphal stages of the three cornered Alfalfa Hopper (Medal, et al., 1995).

Whiteflies

Whiteflies are small piercing and sucking insects. The adults resemble small moths, and the nymphs look like scale insects. They are occasional pests on alfalfa in the Southwest. When populations are large, they can stunt, cause yellowing, or give a mottled appearance to the plants. In extreme cases they can cause defoliation. Like aphids, whiteflies also secrete honeydew that facilitates sooty mold development and lowers alfalfa's quality. Whiteflies' natural enemies include lady beetles, lacewings, minute pirate bugs, bigeyed bugs, predatory mirid bugs, *Macrolophus caliginosis*, the predatory beetle *Delphatus pusillus*, parasitic wasps *Encarcia formosa*

and *Eretmocerus eremicus,* and the insect eating fungus *Beauveria bassiana.*

If populations are not being controlled by natural enemies, an organically accepted pesticide application is advisable. Make sure to use products that are least disruptive to the natural enemies, and check with your certifying organization on which products are acceptable. The cost of the application, the effectiveness of the pesticide, and the price of the commodity all have to be considered. Insecticidal soaps, horticultural oils, and botanical insecticides like pyrethrum (PyGanic®), neem (Neemix®), sabadilla (Red Devil Dust®, Natural Guard®, Veratran D®), and Ryania have been used on piercing and sucking insects with varying success. Check with your certifier before applying any of these products.

Diseases of Alfalfa

Diseases in plants occur when the pathogen is present, the host is susceptible, and the environment is favorable for the disease to develop. Eliminating any one of these three factors will prevent the disease. Organisms responsible for alfalfa diseases include fungi, bacteria, nematodes, and viruses. If these organisms are present, manipulation of the environment and the host to make it less susceptible help to better manage diseases on alfalfa in a sustainable manner. If known diseases are prevalent in your area, check with your seed salesman and request tolerant or resistant varieties.

Soil health and management is the key to successful control of plant diseases. A soil with adequate organic matter can house large numbers of beneficial organisms such as bacteria, fungi, amoebae, nematodes, protozoa, arthropods, and earthworms that in conjunction deter harmful fungi, bacteria, nematodes, and arthropods from attacking plants. These beneficial organisms also help to create a healthy plant that is able to resist pest attack. For more information, see the ATTRA publication *Sustainable Management of Soil-Borne Plant Diseases*.

The leaf surface can also host beneficial organisms that compete with pathogens for space. A disease spore landing on a leaf surface has to find a suitable niche for it to germinate, penetrate, and infect. The more beneficial organisms on the leaf, the greater the competition for the spore to find a niche. Applying compost teas adds beneficial microorganisms to the leaf, making it more difficult for diseases to become established. For more information on foliar disease controls, see the ATTRA publications *Notes on Compost Teas*, *Use of Baking Soda as a Fungicide*, *Organic Alternatives for Late Blight Control on Potatoes*, and *Powdery Mildew Control on Cucurbits*.

Root and Crown Diseases

Damping off is caused by soil fungi such as *Fusarium, Pythium, Phytophthora,* and *Rhizoctonia.* They attack germinating seeds and young seedlings by infecting emerging roots and cotyledons. Extremely wet conditions are ideal for damping off to develop. Planting deep in cool soil delays emergence and makes the seedlings more susceptible to disease. Some work has been done on biological control of damping off in alfalfa using *Streptomyces* (Jones and Samac, 1996) and *Bacillus cereus* (Handelsman, et.al., 1990).

Phytophthora root rot (*Phytophthora megasperma*) is a water-mold fungus that thrives in saturated, poorly drained fields. Good land preparation, careful irrigation management, and the use of resistant varieties are cultural practices that can keep this disease under control. After a hay cutting, irrigation management is critical, since older plants that have their shoots removed showed significantly more *Phytophthora* damaged than younger plants under the same saturated conditions (Barta and Schmitthenner, 1986). Symptoms include yellowing and defoliation of older leaves, wilting, and slow growth of plants. Infected plants pull up easily, with roots and crowns breaking off due to rot. Roots may exhibit red, brown, or black lesions, but they can recover if conditions that favor this pathogen cease.

examples of alfalfa with Phytophthora root rot

Stagonospora Rot (*Stagonospora meliloti*) is a fungal disease that attacks the crown and roots of the alfalfa plant. Symptoms on the leaves are irregular tan spots with brown borders. As the spots enlarge they form concentric rings, with small, round black spots forming in the center of the tan spots. The spores are released from these small black spots and are dispersed by splashing water from rain or irrigation. Symptoms on a cross section of the tap root consist of reddish spots on the tissue. There are no known resistant varieties.

Rhizoctonia (*Rhizoctonia solani*) is a fungus that creates necrotic spots or cankers on roots, crowns, and stems and will cause blight on leaves. It is promoted by wet soil conditions and high temperatures. Root damage in established plants appears as round and oval lesions (cankers) on the taproot. During the summer when the pathogen is active, the lesions are brown to tan in color, while during the winter the lesions are black. There are some alfalfa varieties that are tolerant.

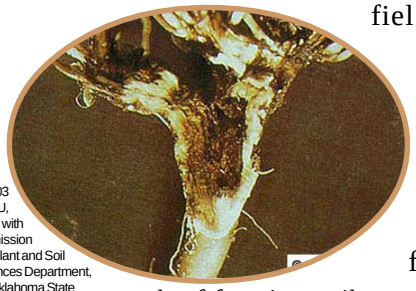
Anthracnose (*Colletotrichum trifolii*) is caused by a fungus that develops in warm, humid weather. Spores are splashed from infected plants to healthy ones during rainfall or by irrigation. Diamond-shaped lesions with dark borders appear on the stems, and the upper portions of these stems will wilt and become hook shaped. The foliage on these stems will become clorotic (loose green color) and die. Alfalfa varieties resistant to anthracnose are available. Induced resistance to *Colletotrichum trifolii* has been achieved in alfalfa by inoculating the plant with other *Colletotrichum* species such as *C. malvarum*, which causes anthracnose on hollyhock (*Althaea rosea)*, and *C. gloeosporioides* (O'Neill, Elgin, and Baker, 1989). Equipment that has been used to harvest alfalfa infected with anthracnose should be disinfected before moving to other fields.

examples of plants with anthracnose

Bacterial Wilt (*Corynebacterium insidiosum*). Plants infected with this bacterium exhibit yellowish, stunted leaves and shorter stems than healthy plants, and they will re-grow more slowly after harvest. A cross-section of the root will display ring-like discolored vascular tissue that interferes with water transport. The bacteria initially enters the plant through wounds caused by harvesting, insects, or nematodes. Cultural practices include the use of resistant varieties, avoid harvesting when plants are wet, harvest healthy stands first, and cleaning equipment when changing fields.

Sclerotinia rot (*Sclerotinia sclerotiorum* or *S. trifoliorum*) attacks alfalfa plants under cool and wet conditions. The fungus attacks the stems and crowns, eventually wilting the plant and producing a soft rot of the infected tissue. If conditions are favorable, white fungal bodies (mycelium) are visible. They then produce the black resting spore structures (sclerotia) on the infected tissue and surrounding soil. The sclerotia, which survive in the soil, germinate to produce small structures called apothecia. The apothecia release tiny spores (ascospores) that land on the plants and begin the infection cycle. The sclerotia can also produce the mycelium that can infect the plant directly. Where this disease has been a moderate problem, the use of resistant varieties is recommended. Deep plowing will bury sclerotia, but this resting spore can be viable for many years if the environment is dry. Eventually the disease remerges after a few seasons. Solarization of soils infected with *Sclerotinia sclerotiorum* reduced the viability of the sclerotia at 5cm, 10 cm, and 20 cm after 15 and 30 days and nullified them after 45 days (Cartia and Asero, 1994). In alfalfa seed production, autumn burning of infected alfalfa fields reduced sclerotia by more than 95% and increased seed yields by 43% in Washington state (Gilbert, 1991).

Fusarium Wilt (*Fusarium oxysporum* sp. *medicaginis*) causes the leaves and stems of the alfalfa plant to yellow and wilt, eventually killing the plant and turning it white. The tap root cross section will show a reddish-brown discoloration. In an infected field only some plants will show symptoms. In infested soils the fungus may persist for five years or more. Infec-



example of fusarium wilt

tion is through wounds on the roots caused by insects or mechanical injury, and through the tiny secondary and tertiary feeder roots. Cultural controls consist of resistant varieties, reduction of plant stress through proper irrigation and nutrition, avoidance of mechanical injury, clean harvesting equipment, and rotation with grains or grass forages. Inoculation of alfalfa seedlings with vesicular arbuscular mycorrhizal (VAM) fungi (*Glomus spp.*) produced a lower incidence of wilt than non-mycorrhizal plantings, and the number of *Fusarium* and *Verticilium* spores were lower in soils inoculated with VAM fungi than in non-mycorrhizal soil (Hwang, Chang, and Chakravarty, 1992).

Phymatotrichum Root rot (*Phymatotrichum omnivorum*) is commonly known as Texas root rot and infects more than 2000 species of broadleaf plants. This fungus is active in alkaline soils and prefers the hot summer temperatures of Texas and the Southwest. Infected plants will exhibit water stress and wilt during the summer, and when pulled will break off below the crown. The vascular system near the crown will be brown and the roots rotten. The infected area in an alfalfa field will grow outwards as the disease spreads, forming a ring pattern. After humid and rainy weather, tan spore mats 8 to 12 inches in diameter may form on the soil near the edge of these ring patterns. Extended rotation with corn, sorghum, or other grains may reduce the severity of the disease.

Texas root rot

Foliar Diseases

Downy Mildew (*Peronospora trifoliorum*) is a foliar disease that occurs when weather conditions are cool and wet. It appears as a grayish-white, powdery growth (spores) on the bottom side of the leaves. The corresponding top portion of the leaves will be yellowish. Once the disease becomes systemic it will stunt the plant, thickening the stems and distorting leaves. The initial infection occurs as spores germinate on wet leaves. Once the weather warms up and the environment becomes drier, the disease will cease until the conditions for its development once again become favorable. Resistant varieties, seeding in spring instead of autumn, and early harvest in spring are cultural practices that may reduce the severity of this disease.

example of downy mildew

Stemphylium Leaf Spot (*Stemphylium botryosum*) is a unique fungal disease in that various biotypes display different symptoms on alfalfa in different parts of the U.S. In the West, spots are irregular in shape, tan in color with dark borders, and do not increase in size. Cool, wet weather favors this biotype's development. In the East and Midwest the spots grow and coalesce to form a larger blighted area, often with a series of concentric rings. Heavily infested plants can lose their leaves and die. This biotype prefers warm temperatures and is more of a threat in the summer and early fall. Resistant varieties and early harvest are recommended to deal with this disease.

Black Stem (*Phoma medicaginis*) appears as small black or brown spots on leaves and stems of alfalfa. As the fungal disease progresses the spots coalesce into larger spots that cover the leaves and stems. Lesions on the stem may girdle the plant, turning the leaves yellow and eventually killing the plant. The organism may also invade crown tissue and cause crown rot. Good soil fertility and harvesting at regular intervals will increase plant vigor and help plants tolerate the effects of the disease.

Common Leaf Spot (*Pseudopeziza medicaginis*) develops small brown to blackish spots on alfalfa leaves. In the center of these dark spots are the fungal fruiting bodies that disperse spores during wet weather. When conditions are right, this disease can spread quickly through a field. Infected leaves will have many spots, turn yellow, and fall off the plant. This disease effects the quality and quantity of the forage. Once the weather warms and dries, the disease cycle stops, but older leaves and debris will provide inoculum

once it cools. Resistant varieties and early harvest are recommended cultural controls. In a conventional alfalfa study, adequate potassium fertilization (65 lbs / a.) was shown to reduce the severity of common leaf spot disease on alfalfa (Grewal and Williams, 2002).

Nematodes

Plant parasitic nematodes are microscopic worm-like animals that attack plant roots, creating galls that limit water and nutrient uptake. This results in weakened plants that are susceptible to further pest attack. Nematode control is essentially prevention, because once a plant is parasitized it is impossible to kill the nematode without also destroying the host. The most sustainable approach to nematode control will integrate several tools and strategies, including cover crops, crop rotation, soil solarization, least-toxic pesticides, and plant varieties resistant to nematode damage. These methods work best in the context of a healthy soil environment with sufficient organic matter to support diverse populations of microorganisms. A balanced soil ecosystem will support a wide variety of "biological control" organisms that will help keep nematode pest populations in check. For more information on nematodes and their controls, request the ATTRA publication *Alternative Nematode Control*.

Alfalfa Stem Nematode (*Ditylenchus dipsaci*) is one of the few species of nematodes that feeds on above-ground plant parts. Alfalfa symptoms include sections of stunted plants with distorted leaves. Stem internodes are short and swollen, and some stems may turn white. These symptoms appear on spring regrowth or after the first or second cutting of an established field. Control methods include sanitation, such as cleaning equipment from infected fields before moving to other fields, and preventing runoff irrigation water from entering clean fields. Wind-blown dry alfalfa also has the potential to transport alfalfa stem nematodes to clean fields. Other cultural practices are using resistant varieties, clean certified seed, and crop rotation for two to three years with non-host crops such as small grains, corn, cotton, beans, or tomatoes.

stem nematode damage

Root Knot Nematodes (*Meloidogyne spp.*) can cause galling, excessive branching of lateral roots, and stunt growth of stems and leaves. Root knot galls are distinguished from nitrogen-fixing nodules by their refusal to dislodge from the root when rubbed. This nematode is sometimes implicated in interaction with other pathogens such as Phytophthora root rot, Fusarium wilt, and Bacterial wilt. Cultural controls include the use of resistant varieties and irrigation and nutrient management to avoid plant stress. Crop rotation does not provide adequate control because of the wide range of hosts that the root knot nematode attacks.

Root Lesion Nematodes (*Pratylenchus spp.*) have a wide range of hosts and are most active in sandy soils. The above ground symptoms can be confused with other disorders that cause stunting and nutrient deficiencies. The roots exhibit reduced growth and dark brown or black lesions on the root epidermis. These lesions may coalesce and turn the entire root dark brown or black. Attacks by the root lesion nematode can allow secondary infection by other disease organisms. Root lesion nematode resistant varieties of alfalfa and fallowing for a couple of months following residue incorporation are suggested cultural controls.

Vertebrate Pests

Alfalfa provides a very desirable habitat for several mammal pests. Besides feeding on the nutrient-rich succulent leaves, stems, and roots, mammals may burrow into levees and ditches and damage irrigation systems and harvesting equipment. Mammal pests of alfalfa include mice, gophers, ground squirrels, rabbits, and deer. Proper identification of the species involved is critical, because control measures differ with each one. Assistance in correctly identifying the animals causing the damage is available through the local Extension service.

Field Mice (*Mictotus spp*), also called meadow voles, dig short, shallow burrows and

make underground nests, creating trails about two inches wide that lead from their burrows to surrounding areas of the field where they feed. Control measures consist of cutting the surrounding vegetation in ditches and adjacent fields, trapping (which can be impractical when populations are high), the use of ammonium-based repellents (check with certifier), and habitat creation for raptors and mammal predators such as coyotes, foxes, wildcats, weasels, and shrews.

Gophers (*Thomomys spp.*) are burrowing rodents that feed mostly on underground plant parts, with alfalfa being one of their preferred foods. Besides weakening or killing the plants, they also damage irrigation ditches and borders. The mounds of soil they push up from their burrows also bury other plants and cause obstacles for the harvesting equipment. Non-toxic controls consist of trapping, flooding the burrows, surrounding a field with plants that repel gophers, such as gopher spurge (*Euphorbia lathyrus*) and castor bean (*Ricinus communis*). Depositing predator urine, pine oil, or any other foul smelling substances in the burrows has been reported to provide temporary control. The use of barn owl perches to attract these predators has been successful in controlling gophers in California. On average, a barn owl can eat 155 gophers per year (Power, 2003). Propane devices that ignite injected gas, causing the burrows to explode, are reported effective in reducing populations temporarily. Check with your certifier before using this method. Additional treatments are necessary, depending on the length of the season.

Ground Squirrels (*Spermophilus spp.*) damage alfalfa by feeding on leaves, stems, and crowns. Their burrows damage plant roots and irrigation levees and create obstacles for field equipment. Controls include trapping, removing rocks and stumps at the edges of fields that provide a desirable habitat, deep tillage to disrupt the burrow system, and shooting. Repellents such as pepper spray, mothballs, and predator urine have been used around plants and burrows with varying success. Again, check with your certifier before using any of these.

Rabbits (*Sylvilagus spp.*) and Jackrabbits or Hares (*Lepus spp.*) can be kept out of alfalfa fields with fencing that is at least four feet high and buried at least six inches. Habitat establishment or conservation to encourage natural enemies such as hawks, owls, eagles, coyotes, foxes, and wildcats is recommended if rabbits are a persistent problem. Modification of the rabbits' environment by removing debris and vegetation where they hide is another cultural control. Repellents, frightening devices, traps, hunting, and domestic dogs and cats, can also contribute to reducing rabbit numbers.

Deer and other large grazers such as elk and antelope can cause significant damage to alfalfa plantings. Several methods to control these large mammals have been used with varying levels of success. Odor repellants and devices that produce periodic explosions can be effective for limited periods, but are not long-term solutions because the animals grow accustomed to them. Fencing is probably the most effective method to protect large fields. The use of guard dogs, an odor repellent, and no treatment were compared at a pine seedling plantation in Missouri for protection against grazing deer. The dogs were a better deterrent than Hinder (odor repellent) or no treatment. Browse rates averaged 13, 37, and 56%, respectively, for dogs, Hinder, and no treatment during the three-year study. Browsed seedlings were generally heavier in weight on plots protected by dogs, suggesting that browsing severity was also reduced (Beringer, et al., 1994). For more information on controlling deer, request the ATTRA publication *Deer Control Options*.

Weed Control

Strategies for non-herbicidal weed control include interseeding alfalfa with annual or perennial grasses, harrowing, grazing, and using nurse crops during establishment. Additionally, anything that can be done to help the crop grow better and thus compete with weeds better should be done. These practices include adequate lime and fertility, planting well-adapted varieties, choosing a well-drained site, rotating alfalfa with annual crops to interrupt the buildup of certain weeds, and cutting alfalfa at the proper growth stage. For spring-seeded alfalfa, a nurse crop of any one of the early-maturing spring grains will help suppress weeds during the alfalfa's establishment period. Peas or oats are common companion crops intersown with alfalfa. Seeding alfalfa stands with annual grass crops such as oats reduces weed pressure through direct competition. These mixed stands of alfalfa and oats make good hay for the horse market. On-farm studies in Wisconsin (Bowman, 1992) during 1988 and

1989 showed only 1% weed infestation in a brome-alfalfa-trefoil mix. A timothy-alfalfa mix had 14% weeds (mostly grasses), and an orchardgrass-alfalfa mix had 21% weeds—again, mostly grasses. Quackgrass often invades aging alfalfa stands. In these studies, the brome- and orchardgrass-mixed plots were quack-free through the second year of the study. Dairies usually require pure alfalfa hay, so the economic impact of selling mixed hay vs. pure alfalfa should be noted. The grade of the alfalfa hay dictates price, with "Supreme" demanding the higher price, followed by "Premium", "Good," "Fair," and "Utility." This system is also used for mixed hay, but a "Premium" mixed hay price may be reduced to the price for a "Good" alfalfa hay, if there is interest in the mixed hay. For more information on feed quality, check the University of Nebraska Cooperative Extension Web page at: http://www.ianr.unl.edu/pubs/Range/g915.htm.

For a mixed stand, reduce the alfalfa seeding rate to 8 to 10 pounds per acre in combination with a reduced rate of perennial grass seed. If an oat or barley nurse crop is to be used, seed 1 to 2 bushels of oats (32 to 64 lbs) or 1 bushel of barley (48 lbs) per acre along with the alfalfa and perennial grass mixture. For best alfalfa establishment, harvest the small grain nurse crop in the boot stage, or just before it forms a seed head. Caution must be taken during fall seeding in dryland conditions, because the small grains use the moisture faster than the alfalfa seedlings, resulting in poor stand establishment.

It is important to get a good stand established during the first year because of autotoxicity concerns. Mature alfalfa (more than one year old) produces a chemical called medicarpin that is toxic to younger plants. This chemical is concentrated on the leaves and stems, so reseeding after harvest is recommended on mature plantings. Medicarpin is water soluable; a good rain or irrigation can leach this chemical past the root zone. For more information on alfalfa autotoxicity, visit the America's Alfalfa Web site at: http://www.americasalfalfa.com/chapters/autotoxicity.htm

Rotations including short-duration alfalfa (2–3 years) are appropriate for sustainable and organic production systems. A thick alfalfa stand will suppress weed growth, provided that weeds do not become a problem during the establishment phase. Stands tend to thin out after four to five years, however, because alfalfa contains a substance toxic to its own seedlings. Weed control can become especially difficult at this point.

Weed control during the establishment phase is critical. Failure to have weeds under control following a planting will result in crop failure. Fall plantings generally result in fewer weed problems than those done at other times of the year (Mortenson, 1992). After primary tillage, the field can be allowed to sit for 7 to 10 days and the weed germination observed. Two or more discing passes may be necessary to reduce germinated weed seed. After that, apply compost, boron, and other nutrients the soil test calls for and till into the soil. Another week or so can be allowed to check for weed growth. If none, the field is ready to plant.

Economics and Marketing

Organic dairies are the primary buyers of organic hay. Organic soybeans can serve as a substitute protein source for organic dairies. Under these circumstances, organic hay prices may move parallel to the price of organic soybeans. Much of the organic soybean market is in Japan, and when they are paying $20 per bushel for soybeans, few beans are going for animal feed. Premiums for organic hay are, at a minimum, 10 to 15% (Lehnert, 1998). Premiums for organic hay may go as high as 40 to 50% when few substitutes exist (Lehnert, 1998). As with any hay market, quality affects price. Moldy or over-mature hay will bring lower prices.

Budgets for organic alfalfa hay production can be found at most county Extension offices. The figures presented in Table 2 are adapted from a conventional budget for an organic farming situation. The two primary differences between organic and conventional alfalfa budgets will be fertilizer type (manure vs. commercial fertilizer) and pest control (organic and biological pesticides vs. conventional pesticides). The actual figures will vary

Table 2. Estimated Organic Alfalfa Hay Production Costs

Item	Unit	Quantity	Price	$/ac	Your Farm
Variable Expenses					
Fertility (Manure)	ton	10	12.00	120.00	
Lime	ton	1	18.00	18.00	
Insect Control (approved chem.)	acre		155.00	155.00	
Twine	bale	140	0.04	5.79	
Machinery					
Fuel	acre	1	2.76	2.76	
Oil and filter	acre	1	0.41	0.41	
Repairs and Maintenance	acre	1	21.72	21.72	
Labor	hour	5.62	8.00	44.99	
Interest on operational capital (6 mo.)	acre	10%	0.10	18.84	
Total Variable Expenses				387.51	
Fixed costs					
Establishment costs (25%/year)	acre	1	35.07	35.07	
Machinery					
Depreciation	acre	1	21.05	21.05	
Interest on operation capital (6 mo.)	acre	1	30.22	30.22	
Housing and Insurance	acre	1	2.13	2.13	
Total Fixed Costs				**88.47**	
Total Budgeted Expenses				**475.98**	

Table adapted from: http://economics.ag.utk.edu/budgets.html#forage

from region to region and from farm to farm. The blank space to the right of each row is provided for your estimated costs. One useful Web site where conventional alfalfa budgets can be found is http://economics.ag.utk.edu/budgets.html#forage.

Summary

Demand for organic dairy feed makes alfalfa an attractive crop for some organic farmers. Fertility sources include a variety of mined mineral-bearing rock powders, animal manure, and compost. Alfalfa can be attacked by a variety of insect pests including alfalfa weevils, various caterpillars, aphids, and leafhoppers. Controls for alfalfa weevil include flaming in the fall, planting a mixture of alfalfa and a grass, and strip harvesting the crop to maintain populations of beneficial insects. Caterpillars can be controlled by several different insecticides derived from the fungus *Beauveria bassiana*, the bacteria *Bacillus thuringiensis*, or several egg parasites that are encouraged from natural populations or released into the field in substantial numbers. Leafhoppers and aphids are generally controlled by a number of natural enemies that are encouraged to stay in the field. Several diseases also plague alfalfa, including various root and crown rots, wilts, and foliar diseases most of which can be controlled by proper field dranage. Alfalfa also attracts several rodents, rabbits, and deer that consume the crop and reduce yields. A variety of organic methods to limit losses associated with these pests are available. Weed control strategies include interseeding the stand with grasses, harrowing, grazing, and using nurse crops during establishment. Adequate lime and soil fertility allow the stand to compete with weeds.

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608–254–7842

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http://www.uwex.edu/ces/crops/uwforage/alfalfa.htm

University of Minnesota, Alfalfa IPM
http://www.ipmworld.umn.edu/chapters/flanders.htm

North American Alfalfa Improvement Conference
http://genes.alfalfa.ksu.edu/

Forage Information System, Oregon State University
http://forages.orst.edu/

California Alfalfa & Forage Systems Workgroup
http://alfalfa.ucdavis.edu/

Forages Information from Pennsylvania State University
http://www.forages.psu.edu/

Oklahoma State's Alfalfa Production Information
http://alfalfa.okstate.edu/index.htm

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