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Alfalfa Seed Production in California

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UNIVERSITY OF CALIFORNIA
Division of Agriculture and Natural Resources
Publication 8308
5/2008
http://anrcatalog.ucdavis.edu

Chapter 22

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This publication is **Chapter 22** of a 24-chapter series on Irrigated Alfalfa Management published by the University of California Alfalfa & Forage Systems Workgroup. Citation: Mueller, S. C. 2007. Alfalfa seed production in California. IN C. G. Summers and D. H. Putnam, eds., Irrigated alfalfa management in Mediterranean and Desert zones. Chapter 22. Oakland: University of California Agriculture and Natural Resources Publication 8308. See: http://alfalfa.ucdavis.edu/IrrigatedAlfalfa

California is an ideal location for production of high quality alfalfa seed. Although seed production has declined in recent decades, this state remains the primary producer in the United States. Nondormant varieties (fall dormancy [FD] ratings of 7–10) are the dominant varieties grown for seed in the Mediterranean and Desert zones of California, particularly Fresno, Kings, and Imperial Counties.

Alfalfa seed produced throughout the world is primarily used for forage production. Seed is planted to produce alfalfa for grazing, greenchop, silage, baled hay, cubes, or pellets to support the livestock industry, including dairy, beef, horses, goats, and sheep. A very small fraction of the total production is used by the sprout industry. This chapter provides an overview of alfalfa seed production techniques in California.

Scope of the Seed Industry

Approximately 80 million pounds (36.3 million kg) of alfalfa seed are produced in the United States each year (Fig. 22.1). Eighty-five percent of that total is produced in the five western states—California, Idaho, Oregon, Washington, and Nevada. U.S. acreage ranged from 60 to 75 thousand acres (24 to 30 thousand hectares) between 2002 and 2006, but was greater than 150,000 acres (60,000 ha) during the 1990s. The balance of the seed

FIGURE 22.1

Alfalfa seed production for the five western states.

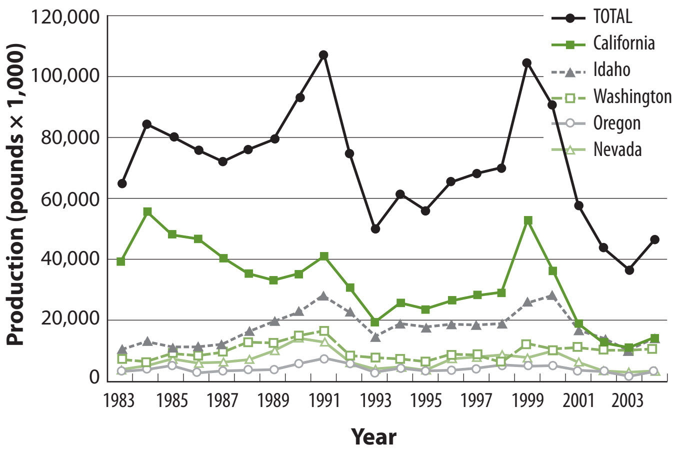


FIGURE 22.2

Alfalfa seed acreage for the five western states.

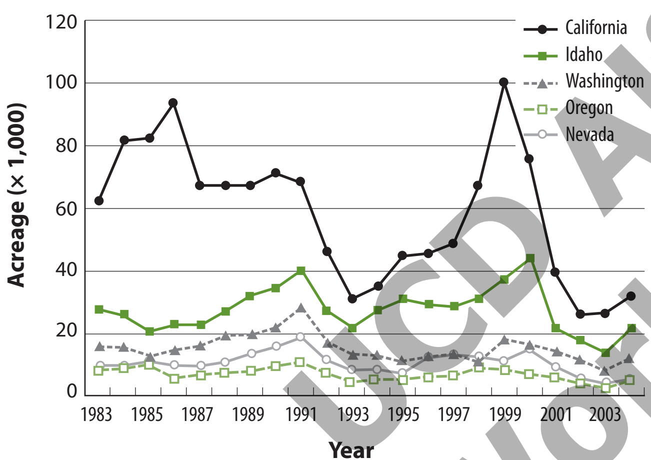
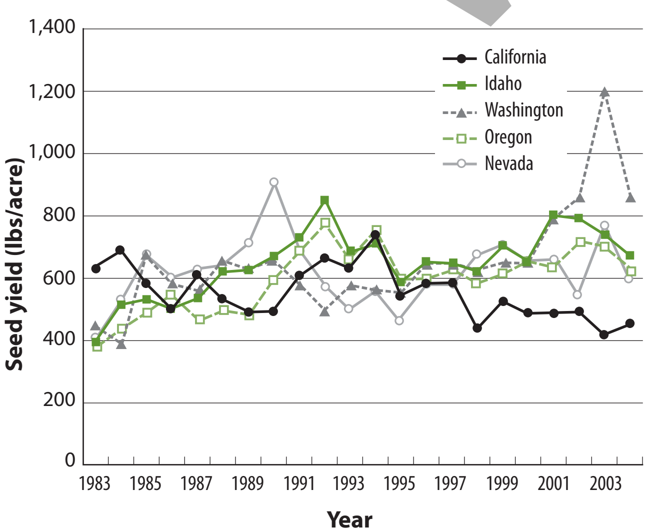


FIGURE 22.3

Alfalfa seed yield for the five western states.



comes primarily from Arizona, Utah, Montana, and Wyoming. Seed production systems in each of these states are tailored to balance the climate and soil conditions with management to optimize seed yield and quality.

Historically, California has been the largest supplier of alfalfa seed in the United States. However, due to changes in economics, environmental constraints, and regulatory issues, acreage in California has declined (Fig. 22.2). As acreage decreased in California, expansion in Idaho and other northwestern states maintained U.S. supplies at a nearly constant level. Production on a per-acre basis has been fairly steady within a given seed-producing region (Fig. 22.3). Production in California is located in the central San Joaquin Valley (Fresno and Kings Counties), the Imperial Valley, and in Yolo County, near Sacramento.

Ninety-five percent of the seed produced in California is of nondormant varieties (FD 7–10). A significant percentage of California's production is exported. The Pacific Northwest produces seed of semidormant (FD 5–6) and dormant (FD 2–4) varieties. Seed of a specific dormancy class is normally produced in its area of adaptation to prevent genetic shifts.

Stand Establishment

Site Selection

Alfalfa seed production is well adapted to the arid climates of the western United States. A warm, dry production and harvest season is important to maximize seed yield and quality. Alfalfa seed production is best suited to deep, well-drained soils; heavier clay or loam soils are preferred over lighter, sandy soils. Seed fields in California are irrigated, and heavy soils, characterized by high water holding capacity, are more easily managed for seed production. Soils should be low in alkali and in soluble salts; however, salt-tolerant varieties can produce high seed yields in saline soils. Alfalfa seed can be grown on soils with a shallow water table (3–4 feet [0.9-1.2 m] from the surface) if special care is taken with respect to irrigation and field management.

Time of Seeding

Properly timed production practices are the key to high seed yield and quality. Successful seed production begins with proper stand establishment. The majority of seed alfalfa stands are established in the fall. The recommended planting dates are the same as for alfalfa forage production (mid-September through October in the central San Joaquin Valley); however, growers are often forced by constraints of their crop rotations to schedule later planting dates. If planting takes place during the winter months (November–January), alfalfa seed germinates and emerges slowly, giving winter weeds a competitive advantage, thereby hampering stand establishment. Spring (February) establishment of alfalfa seed fields is possible, but the seed harvest is later and yield for that year will be lower. Recommended land preparation procedures used for planting alfalfa hay in the area should be followed when establishing stands for seed production. See Chapter 4, "Stand Establishment," for specific information regarding planting recommendations.

Solid Versus Row Planting

Where alfalfa stands are dedicated to seed production, growers most often plant in rows. If the grower plans to take forage from the field as well as a seed crop, then solid plantings will give higher forage yields. A grower must consider the difficulties imposed by managing a field for both seed and forage, as compared to the individual crop options. Dense stands maximize hay production, but typically produce lower seed yields than thinner stands. In addition, chemicals used in the production of the seed crop often limit the future use of the field for forage production. In some areas, certified seed production requires that the field be planted in rows to enable assessment of volunteer alfalfa control.

Row-planted fields may be flat planted or planted on beds (Fig. 22.4). Bed planting is usually more successful than flat planting because early cultivation for weed control is possible, and it permits furrow rather than flood irrigation. The distance between the rows or beds is usually determined by the growth potential in that location, which is influenced by soil texture, water availability, variety, and length of the growing season. If the plants tend to grow vigorously in a given area, wider row spacing (40 inches [102 cm]) may be preferred over a narrower spacing (30 inches [76 cm]) used when smaller plants are produced.

A number of interacting factors contribute to higher yield and quality from thinner, row-planted stands:

- Water management is enhanced when seed fields are planted on beds.
- Honey bee pollination is improved in thinner stands since bees have better access to bloom.
- The efficacy of pesticide applications increases due to better spray penetration within the canopy.
- Volunteer alfalfa and weed control is easier to assess and carry out.
- Desiccation in preparation for harvest is optimized.
- There is less lodging of the canopy, which improves overall seed quality.

FIGURE 22.4

Alfalfa seed production in rows on a bedded production system.

TABLE 22.1

First and second year alfalfa seed yields from plant spacing trial, Mendota, CA; all treatments were on beds in 30" (76 cm) rows

Planting Date, Variety, and Seeding Treatment	Spacing (inches)[1]	Yield (pounds/acre)[1] 1990	Yield (pounds/acre)[1] 1991
Fall Planted (11/5/89) Variety: CUF 101			
Unthinned Control	Unthinned[2]	621	1,397
Thinned	Thinned[2]	647	1,473
Spaced	4	740	1,482
Spaced	8	684	1,418
Spaced	12	727	1,378
Spaced	18	726	1,382
	LSD (0.05)[3]	ns	ns
	CV (%)[3]	7.27	7.10
Spring Planted (3/1/90) Variety: WL 605			
Unthinned Control	Unthinned	487 b	1,321
Thinned	Thinned	567 ab	1,349
Spaced	4	607 a	1,395
Spaced	8	644 a	1,371
Spaced	12	653 a	1,294
Spaced	18	639 a	1,311
	LSD (0.05)	93.7	ns
	CV (%)	8.59	4.82
Comparisons[3]			
Fall Planted—Unthinned vs. thinned and spaced plantings	Significance	*[3]	ns
Spring Planted—Unthinned vs. thinned and spaced plantings	Significance	**	ns
Fall Planted—Unthinned and thinned vs. spaced plantings	Significance	**	ns
Spring Planted—Unthinned and thinned vs. spaced plantings	Significance	**	ns

[1] To convert inches to cm, multiply times 2.54. To convert lb/acre to kg/ha, multiply by 1.12.

[2] Unthinned = 1.5 lbs/acre seed (approx. 15 plants/foot). Thinned = 1.5 lbs/acre seed in solid planted rows that were later thinned to alternating areas of 6 inches of planted space and 6 to 12 inches where plants are removed.

[3] LSD = Least Significant Difference at P≤0.05. Values followed by the same letter are not significantly different; C.V. = Coefficient of Variation. Comparisons are orthogonal comparisons: * = Significant at P=0.05, **=Significant at P = 0.01, ns = nonsignificant by F-test.

Plant Population (Seeding Rate)

The density of plants in the entire field, or within an individual row, has a direct effect on alfalfa seed yield. Improved water use efficiency, pest control, and pollination are thought to be factors contributing to higher yields in thinner stands. In addition, higher seed yields may be associated with higher levels of carbohydrate reserves in plants. Plants with high root reserves produce more stems, more pods per stem, and more seeds per pod than plants with reduced carbohydrate concentrations.

Stand density can be controlled either by reducing the seeding rate or by thinning the stand once plants emerge. There are risks associated with both of these approaches. Low seeding rates have a higher risk of stand failure if adverse conditions prevail. On the other hand, weather conditions may prevent equipment or crews from entering the field at the optimum time for thinning, which may impact seed yield. Planting at very low seeding rates requires pelleted seed and precision planting equipment. Excellent alfalfa stands for seed production have been successfully established with 0.5 to 0.75 pounds (0.2–0.3 kg) of seed per acre or less in row plantings, and 6 to 10 pounds (2.7–4.5 kg) of seed per acre in solid stands.

The plant density required to optimize seed yield depends on row spacing and soil type, which influence growth and final size of the alfalfa plant. In a 1990 trial on a clay loam soil, solid row plantings and conventionally thinned plantings were compared with plots planted using precision equipment to place individual seeds from 4 to 18 inches (10–46 cm) apart. Fall and spring planting dates were evaluated. All rows were planted on beds spaced 30 inches (76 cm) apart. In the first year, plantings with seed spaced from 4 to 18 inches apart produced higher yields than solid plantings or thinned plantings (Table 22.1). Differences in water use efficiency and maturity were also noted. In the second year of the trial, there were no significant differences in seed yield when spaced plantings were compared with solid or hand-thinned plantings.

Seeding Methods

When planting, seed depth should not exceed 0.5 inch (1.3 cm). Alfalfa seed is small and has only a limited amount of reserves to carry the seedling through to emergence. Poor stand establishment with uneven emergence and skipped areas will result if the seed is planted too deep or into a poorly prepared seedbed. If the field does not have a history of alfalfa production, inoculation of the seed with the proper *Rhizobium* bacteria is desirable prior to planting to ensure adequate nodulation for nitrogen fixation.

Seed may either be planted to moisture or irrigated following planting. The surface layer of soil must stay moist to promote uniform germination and seedling establishment.

Cultural Practices

Thinning of Stands

Using traditional management practices, thinner stands are an advantage in seed production. The common practice has been to plant a solid row and later thin the row to alternating areas of 6 inches (15 cm) of planted space and 6 to 12 inches (15–30 cm) where plants are removed using a hoe or by cross disking. First-year stands are thinned when the seedlings are in the two- to four-trifoliolate leaf stage. Mechanical thinning can be used if the stand is uniform with three to five plants per foot. However, hand hoeing is preferred if the stand is not uniform since large skips in the row can be avoided. In established stands, most growers thin in the fall, after harvest, by cross disking or "cross-blocking." Since the adoption of alfalfa leafcutting bees (*Megachile rotundata* (F.)) for pollination in the central San Joaquin Valley, most growers do not believe it is necessary to thin alfalfa seed fields to achieve maximum yields.

Clipback

Once the stand is established, fields are clipped in the spring (early April in the central San Joaquin Valley) to initiate the seed production season. The clipping may be a forage harvest, chopping, chemical clipping, or taken by grazing sheep, depending on grower preference and previous pesticide use in the field. The field should be coming into bloom at the time of clipback, or initial seed set may be reduced due to the negative impact on root reserves. The purpose of clipback is to encourage plants to come into bloom uniformly and to synchronize bloom with the period in the season when pollinators are most active. Spring clipping also removes growth that has overwintered, and cleans up the field for herbicide applications. Clipback can be followed by light harrowing and row cultivation to control weeds and volunteer alfalfa from the previous harvest. Many growers also cultipack fields immediately after clipback to conserve moisture, firm seed beds, and smooth fields to reduce soil contamination at harvest.

The purpose of clipback is to encourage plants to come into bloom uniformly and to synchronize bloom with the period in the season when pollinators are most active.

Following clipback, regrowth is initiated and the plant blooms approximately 35 to 45 days later. Properly timed and uniformly scheduled within an area, clipback is also used as a cultural method for controlling the alfalfa seed chalcid (*Bruchophagus roddi* Gussakovsky). If all fields are close to the same stage of maturity due to a uniform clipback schedule, seed is not at a susceptible stage of development when peak emergence of chalcid occurs. Early April clipping interrupts the chalcid life cycle and has reduced damage to seed crops by chalcid to less than 0.5 percent from a high of 16 percent in the early 1960s.

Fertilization

Soil tests can provide an indication of the fertility status of a field prior to planting. Specific fertilizer recommendations for seed alfalfa production in the western United States are not currently available. Fertility is considered adequate if the crop is grown in rotation with other crops where fertility is adequate. If a field is known to be deficient in a particular nutrient, apply necessary fertilizers before planting. Most researchers have been unable to detect increases in seed yield as a result of soil or foliar applications of fertilizer containing either major or minor elements.

Supplying Water

In the central San Joaquin Valley, alfalfa grown for seed requires 3.5 to 4 acre-feet (0.43–0.49 ha-m) of water per year as irrigation or effective rainfall. However, the timing of irrigation is a critical aspect of seed production and differs significantly from alfalfa forage production.

First-year seed fields may require less water than established stands because soil moisture often remains after harvest of the previous crop, and the alfalfa has a less-well-developed root system during the establishment year. Approximately 3 acre-feet (0.37 ha-m) of water should be adequate for a first-year stand. Both the timing and amount of water applied in an irrigation can greatly affect the condition of the field and subsequent seed production.

When water is available, fall, winter, and early spring irrigations are applied to fill the soil profile and help moderate summer irrigation extremes. During the season, controlled moisture stress is considered an important component in the water management of alfalfa for seed production. In the Central Valley, two to three flushes of bloom are typically produced from the crown, pollinated, matured, and harvested at one time in early fall. Irrigation must be properly timed during each of the bloom cycles to promote slow continuous growth, bloom, and seed set without severely stressing the plant. If the plants are severely stressed, growth and flower production stops. If too much water is applied, vegetative production is promoted and seed set suffers. Late in the season, adequate moisture must be available to mature the seed crop, but then soil moisture must be depleted or plants will not dry down sufficiently in preparation for harvest. Most irrigation systems are surface systems—flood or furrow—but some seed is grown under sprinkler irrigation. Drip irrigation systems are rare in alfalfa seed fields.

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Irrigation Timing

There are few tools available that allow growers to better time their irrigation events. Gypsum blocks, tensiometers, and neutron probes provide good indications of soil water status, but they may not function properly in the moisture range where growers attempt to pollinate seed fields. They also do not work in areas with shallow water tables. In an irrigation trial conducted in the central San Joaquin Valley from 1988 through 1990, maximum seed yields were associated with treatments that allowed midday plant leaf water potential (LWP) to drop to −2.5 megapascals (MPa) (−25 bars) before irrigation. Later in the season, LWP can be allowed to drop to −3.0 (MPa) (−30 bars) or lower during the preharvest dry-down period.

When timing irrigation, growers take pollinator activity into consideration. Irrigating immediately before introducing honey bees to a field or during peak pollinator activity could be devastating to seed production potential. Honey bees are not as active in recently irrigated fields because of a reduction in the available sugars in the nectar. Growers often stress alfalfa fields to encourage honey bees to pollinate the bloom. When reaching the point where irrigation is necessary, they may time a pesticide application in conjunction with their irrigation to minimize the length of time that honey bees are repelled from the field. Alfalfa leafcutting bees do not show this same reluctance to enter recently irrigated fields.

Weed and Pest Management

Weed Management

In addition to concerns about competition from unwanted plants, weed management in alfalfa seed fields is important because there are strict requirements regarding the purity of certified seed. No primary or secondary noxious weeds are permitted in certified seed fields. From stand establishment through the final cleaning and conditioning process, the goal is to eliminate weeds. In the field, growers use a combination of herbicides, mechanical cultivation, and weeding crews to remove weeds. Volunteer alfalfa plants in certified seed fields should be treated as weeds.

During conditioning, a variety of screening and separation techniques are used to remove foreign material. However, depending on the level of contamination, substantial quantities of alfalfa seed can be lost in the cleaning process, so it is more efficient and economical to control weeds in the field, or at least prevent them from going to seed.

Dodder Control

Dodder (*Cuscuta* spp., primarily *C. indecora* Choisy, *C. campestris* Yunck and *C. planiflora* Ten.) can be a particularly troublesome weed in alfalfa seed fields (Fig. 22.5). There is zero tolerance for dodder seeds in certified alfalfa seed. Dodder is a parasite that lives off the host plant; it has no direct connection to the soil once it has attached itself to the host. To control dodder once it has attached, you must destroy and remove the above-ground portions of the plant. Currently registered herbicides can only control dodder prior to emergence and attachment. However, dodder continues to germinate throughout the production season, when residual activity of herbicides declines. Spot burning, or clipping and carrying dodder-infested plants out of the field, will control late-emerging dodder that attaches to the alfalfa seed plant. Often, the alfalfa is killed in an area during the dodder control process, giving weeds a greater opportunity to encroach.

FIGURE 22.5

Dodder in alfalfa seed.

Dodder seed is one of the most difficult weed seeds to remove during the cleaning process since it is approximately the same size as alfalfa seed. Removal requires a recleaning of the alfalfa seed with a magnetic separator to remove dodder seeds, which usually increases the loss of alfalfa seed from 2 to 15 percent. If dodder seed is not removed, the lot cannot be certified.

Insect Pests

A number of arthropod pests have an impact on the yield or quality of alfalfa seed, or both. Major pests include lygus bugs (*Lygus* spp.), spider mites (*Tetranychus* spp.), and alfalfa seed chalcid (*Bruchophagus roddi*) (Figs. 22.6–22.8). Occasionally stink bugs (*Chlorochroa sayi* Stal and *Euschistus consperstus* Unler) and armyworms (*Spodoptera* spp.) may require control measures. Resistant cultivars of alfalfa have been effective in controlling pea aphid (*Acyrthosiphon pisum* Harris), blue alfalfa aphid (*Acyrthosiphon kondoi* Shinji), and spotted alfalfa aphid (*Therioaphis maculata* Buckton). For this reason, they are only considered to be major pests on susceptible varieties grown for seed in California. The cowpea aphid (*Aphis craccivora* Koch.), which is a shiny, black aphid, has been a sporadic summer pest in black eye beans (*Vigna unguiculata* (L.) Walp), but showed up in high numbers in Desert and San Joaquin Valley alfalfa fields during spring 1999. Hundreds of aphids can develop on a single

FIGURE 22.6

Lygus bug damage to alfalfa. (a) Lygus bug adult, and (b) stem showing stripping at the top of the plant caused by lygus bug feeding.

FIGURE 22.7

Spider mite damage to alfalfa. (a) Close-up photo of leaf damage caused by spider mites, and (b) webbing over leaves and stems caused by spider mites.

FIGURE 22.8

Alfalfa seed chalcid adult (bottom left), and damage from exit hole in seed (center) and pod (right), as compared to an undamaged alfalfa seed (left).

plant, producing large amounts of honeydew and desiccating green tissue. Efforts are underway to develop host plant resistance to this aphid in new alfalfa cultivars.

Beneficial insects in alfalfa seed fields include minute pirate bugs (*Orius* spp.), big-eyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.), and lacewings (primarily *Chrysoperla* spp.). Spiders and ladybird beetles also contribute to management of various pest species. Adults and nymphs of these predators feed on insect eggs and small insects such as thrips, mites, aphids, whiteflies, and small caterpillars.

Insect Monitoring and Pesticide Use

Growers or pest control advisors monitor most pest and beneficial insect populations once or twice each week throughout the season. Both population counts and stage of insect development are used to determine management strategies. Continuous monitoring of predators and pests in the field can result in reduced use of chemicals and improved timing of pesticide applications.

Typically, an insecticide is applied in May before bees are placed in the seed field. During bloom and pollination, multiple applications of pesticides are usually required. To protect pollinating insects, pesticide applicators need to apply chemicals according to their written labels. They should be particularly aware of special instructions, including locations of bee colonies, to avoid or treat with different chemicals, night application start and stop time limits, and inspection of fields for bee activity just before aerial application. Nearly all chemicals used for pest control purposes in seed alfalfa are capable of killing pollinators by direct contact. Visual inspection of colonies must be made to determine if bees are on the outside of the colony boxes before applying insecticides in an area. The condition of colonies, air temperature, and field conditions will vary greatly, so visual inspection before starting a pesticide treatment is the best way to avoid direct contact between pesticides and bees. These same guidelines are recommended for all pesticide applications in regions where seed is grown.

Lygus Control

Lygus bugs (*Lygus* spp.) are among the most significant pest species in alfalfa seed production in California. These pests occur throughout the season, moving between a variety of crops in a region as they become unsuitable hosts due to maturity or harvest. They are by far the most difficult insects to manage in alfalfa seed fields; when present in high numbers they may completely destroy the crop. Both adults and nymphs feed on the alfalfa plant, attacking reproductive parts and causing premature drop of buds and flowers (stripping), seed deformation, and reduced seed viability. Control of the lygus bug is essential to the economic production of alfalfa seed. Action thresholds vary with the stage of crop development (Table 22.2).

Lygus bugs overwinter as adults on a number of winter annuals, in the crowns of alfalfa plants, and in plant debris. The adults become active in the spring, mate, and lay eggs immediately. Approximately 12 to 30 days are required from the time an egg hatches until the insect reaches the adult stage. During this developmental process, lygus bugs pass through five growth stages called instars. All nymphs (immatures) are wingless, so only the adults are capable of flight. Temperature is a major factor in lygus bug development. High temperatures shorten the time required for lygus bugs to pass through the developmental stages. In general, nymphs remain in each of the first four stages of development for 2 to 7 days and remain in the fifth stage for 4 to 10 days. With an average generation time of 6 weeks, there are usually about five generations per year in Central California. If winter and spring are very warm and rainfall patterns have

TABLE 22.2

Treatment thresholds for lygus bugs in alfalfa seed fields.

Alfalfa Growth Stage	Treatment Threshold for Lygus Bugs (lygus bugs/sweep)
Early season (pre-bee)	2–6
Bloom and seed set	8–10
Seed maturation	10–15

provided a continuous food supply, a greater number of generations per year can be produced. The greatest period of lygus bug activity is from June through August.

Degree days can be used to forecast seasonal lygus bug development, especially hatch and migration dates. The dates are forecast using weather averages and predict the beginning of hatch and migration, which will continue for several weeks. This information is available to growers and pest control advisors through the UC-IPM Web site (http://www.ipm.ucdavis.edu/).

Treatment can be delayed until egg hatch is complete but should take place before the nymphs reach the fourth and fifth instar.

Lygus bug populations are monitored using a sweep net. During summer, most pesticide applications are targeted toward lygus bugs. Treatment thresholds are based on the average number of lygus bug nymphs and adults present in 10 to 20 sets of two 180-degree sweeps (see Chapter 9, "Managing Insects in Alfalfa," for an illustration of sweeping). Pesticide applications should be timed to coincide with the hatching of lygus bug brood. Treatment can be delayed until egg hatch is complete but should take place before the nymphs reach the fourth and fifth instar. Older instars and adults are more difficult to control with insecticides than are younger instars. Attempts to develop alfalfa germplasm with resistance to lygus bugs continue. Detailed information on scouting and pest control options is available in the *Pest Management Strategic Plan for Western U.S. Alfalfa and Clover Seed Production,* which can be found online at http://groups.ucanr.org/alfalfaseed/WestAlfalfaCloverSeed.pdf.

Few materials are available for the control of lygus bug in alfalfa seed fields. Because of the limited number of options, and the high potential for the development of resistance, it is critical to maintain the efficacy of currently registered chemicals. Lygus bugs are quickly able to develop resistance to chemicals applied to control them because of several characteristics:

- They have a short life cycle with many generations per year.
- They have a wide host range.
- They are exposed to many insecticide applications each year, not only in seed alfalfa but also in other susceptible crops.

Furthermore, insecticide applications generally eliminate or greatly reduce naturally occurring beneficial organisms, such as parasitic wasps and predatory insects that help keep the pest population somewhat in check.

The best insurance against development of insecticide resistance is rotating chemical controls and maintaining the insect's natural enemies in the field. If control by insecticides is necessary, the best way to reduce resistance development, and in some cases even allow pest populations to become more susceptible, is to alternate insecticides, paying particular attention to the *class* of each insecticide (e.g., pyrethroid or organophosphate) and rotating between classes.

Spider Mites

Each year, alfalfa seed growers in California experience significant problems due to infestations of spider mites. Enclosing stems, leaves, and flowers in sheets of fine webbing and feeding off the lower leaf surface, spider mites can cause considerable damage by interfering with pollination. Consequently, they can reduce yields, or if there is a heavy infestation, kill the entire plant (Fig. 22.7). Spider mites commonly found in California's alfalfa seed fields are twospotted (*Tetranychus urticae* Koch), pacific (*T. pacificus* McGregor), and strawberry (*T. turkestani* Ugarov & Nikolski) spider mites.

Damage caused by spider mites worsens during hot weather. A complete generation of the microscopic mites can be produced in as little as ten days when temperatures are high (> 90ºF [32ºC]). The hot, dry climate of the San Joaquin Valley allows mites to flourish. Damage resulting from spider mite infestations can be substantial. Growers must monitor their fields weekly, examining leaf surfaces to detect the presence of spider mites and watching for the appearance of webbing. Ideally, fields should be treated as soon as an infestation is discovered, unless it appears too late in the season to cause economic damage (i.e., when the seed crop is already made and the field is beginning to dry down).

Alfalfa Seed Chalcid

Alfalfa seed chalcid (*B. roddi*) damage varies from year to year and from field to field. All life stages of the chalcid—eggs, larvae, and pupae—develop within the seed and are protected from insecticides applied to the field. Adults emerge continuously from seed in the field and from adjacent areas, making attempts to manage chalcid populations with insecticides expensive and ineffective. Cultural control strategies, such as clipping fields in the spring (early April) to set the crop early and uniformly, controlling volunteer alfalfa plants in and around seed fields, and irrigating and cultivating fields after harvest to promote rotting of seed and decomposition of debris left in the field, all aid in suppressing chalcid populations. For the most effective results, these practices should be scheduled on a regional basis.

Other Insect Pests

Although the above-mentioned species are the major pests that affect seed production, several common insect pests in alfalfa hay may also affect seed fields. These include the alfalfa weevil (*Hypera postica* Gyllenhal) and Egyptian alfalfa weevil (*H. brunneipennis* Boheman), pea aphid, blue alfalfa aphid, spotted alfalfa aphid, cowpea aphid, and several species of Lepidoptera that occur in summer and fall. Please see Chapter 9, "Managing Insects in Alfalfa," for a thorough review of these pests.

Insect Management Strategies

There are a limited number of options for managing insect pest populations in seed alfalfa fields.

Biological Control. Biological control involves the use of naturally occurring or released predators and parasites. In most cases, biological control can't be relied upon in and of itself to provide economic insect control in seed fields. Recently, a small, native, parasitic wasp, *Peristenus* spp., which attacks lygus bug nymphs, was identified in the Pacific Northwest. Further research may develop strategies whereby *Peristenus* may be used to help suppress lygus bug populations in areas where they overwinter, on early spring hosts, or in other untreated crops.

Cultural Control. Cultural management is of limited effectiveness in controlling most pests in alfalfa seed fields. When strategies are available, they should be used in conjunction with other management methods. The most effective example of cultural control of an insect is the combination of early clipback and fall management strategies used to suppress alfalfa seed chalcid populations.

Chemical Control. Chemical control is currently the most effective and widely used pest management option, but it is not without problems. Chemicals must be carefully selected and applied to kill the target pest without harming pollinators. During bloom, insecticides are applied at night to lessen the impact on pollinators. Most chemicals are applied by air to avoid damaging bloom and seed set by driving through the field. There are few materials available to control the most damaging insect pests in seed alfalfa fields. For that reason, resistance management is an important consideration. Maintaining the susceptibility of insect populations to chemicals is critical. Growers

During bloom, insecticides are applied at night to lessen the impact on pollinators.

and pest control advisors should take into consideration the population of beneficial insects in the field, use selective materials first if possible, and monitor resistance to make informed pest management decisions.

Disease and Nematode Control. Seed alfalfa growers benefit from the pest resistance bred into varieties for forage production. In addition, since stands are often planted on beds in rows, or at lower population densities than forage production stands, diseases are less of an issue.

FIGURE 22.9

Pollinators used in alfalfa seed production in the western United States: (a) honey bees, (b) leafcutting bees, and (c) alkali bees.

Pollination

Alfalfa flowers require tripping and cross-pollination for maximum seed yields. Three types of pollinators are used in seed production in the western United States: honey bees (*Apis mellifera* L.), alfalfa leafcutting bees (*Megachile rotundata*), and alkali bees (*Nomia melanderi* Ck11.) (Fig. 22.9).

Honey Bees

In California, most alfalfa seed producers use honey bees (*A. mellifera*) for pollination. They are inexpensive but are relatively inefficient pollinators. Honey bee inefficiency is due to the fact that only a small percentage of the foraging bees are active pollen collectors. In addition, they prefer most other blooming crops to alfalfa and avoid the tripping mechanism that results in cross-pollination. Due to their inefficiency, honey bees require a long season to pollinate the seed crop. For that reason, they can be used in California, but cannot compete with more efficient, but expensive, pollinators used in other seed producing states. Researchers have attempted to improve the attractiveness of alfalfa to honey bees through plant breeding to enhance seed production, while apiculturists have simultaneously attempted to breed bees with a higher propensity to collect pollen. Both groups of researchers have been successful, but the industry has yet to widely adopt these strategies to improve alfalfa seed pollination.

Honey bees are usually placed in or around seed fields when they are between one-third and one-half bloom. This typically occurs about 45 days following clipback in the central San Joaquin Valley. Timing placement is important; bees placed before adequate bloom is present may leave the alfalfa in search of greater pollen and nectar resources elsewhere. When the bees' requirements can be satisfied by better or more easily worked blossoms, they show no interest in alfalfa pollen. It may be advantageous to place a second set of bees in the alfalfa seed field 3 to 4 weeks after the first colonies are placed to enhance pollination activity as the field comes into full bloom.

Pollinator activity is impacted by production practices such as irrigation and pesticide applications, as well as weather conditions. It takes 20 to 25 days, depending on temperature, to mature seed after pollination. It takes approximately 14 days to progress from the green pod stage to physiological maturity. Given this information, bees should be removed from fields about 30 days before the projected harvest date (allowing 7 days for desiccation). Blossoms pollinated beyond that point would not reach maturity by harvest.

Although pollinator populations (colony strength) and rental fees vary, most growers use two to three strong colonies per acre at a cost of about $35 per colony. Many rental fees are based on colony strength, which can be evaluated by the County Agricultural Commissioner or an independent consultant. A fee to cover the cost will be assessed to the party requesting the inspection and certification.

Leafcutting Bees

Growers in the Pacific Northwest rely on alfalfa leafcutting bees (*M. rotundata*) for seed pollination. Since 1990, many growers in the central San Joaquin Valley of California have come to appreciate the benefits of incorporating leafcutting bees into their pollination systems. Compared to honey bees, leafcutting bees are more efficient, but they are also often more expensive and require a greater degree of management. They are more efficient because each female in the population (approximately one-third of the total population) actively gathers pollen and nectar to provision her nest. Growers use 1 to 4 gallons (3.78 to 15.12 liters—9.35 to 37.4 liters per ha) of bees (10,000 bees per gallon [2,646 per liter]) per acre. Higher labor requirements, significant annual fluctuations in bee prices, the need for incubation, housing, and nest material, as well as a greater sensitivity to pesticides currently limit the exclusive use of leafcutting bees in California. However, leafcutting bees can be used in combination with honey bees, and many growers are taking advantage of this combined pollinator approach to maximize seed yields.

Alkali Bees

Seed growers in a small area of Washington State use alkali bees (*N. melanderi*), which are solitary, soil-nesting bees. Bee beds (nesting sites) are difficult to manage in California cropping systems and, as a consequence, alkali bees are no longer used for commercial pollination here.

Dessication and Harvest

Alfalfa seed fields must be dried before harvest to efficiently separate the seed from the pod and residual plant material. Irrigation is terminated late in the season in preparation for harvest. Once the plants dry to a certain point, the grower prepares the seed crop for harvest by either cutting and windrow curing or chemically desiccating the standing crop.

The Windrow Curing Process

Once the majority of the seed is mature (two-thirds or three-fourths of the pods have changed from green to dark brown in color), a swather cuts the alfalfa at the base of the plant and lays it in windrows on the stubble to air dry in the field. Alfalfa seed should be swathed during periods of high humidity or heavy dew. If windrowing is done under dry conditions, as much as one-half of the seed can be lost. Any green seed that remains on the plant will continue to ripen (mature) in the windrow. Windrows are ready for threshing when the moisture content of the plant is from 12 to 18 percent. In California, windrow curing is most common in the desert regions of the south. In the San Joaquin Valley, low humidity and strong winds during harvest make windrow curing a risky venture. Windrow losses can exceed 50 percent in fields subject to strong winds during curing.

Chemical Desiccation

For spray curing to be effective, the seed field must be mature, open, and erect. Desiccants are usually applied to fields 7 to 10 days before harvest. The chemicals dry the leaves and the stems of the plant without inducing defoliation. One application can sufficiently desiccate a light field in approximately 5 days. Heavier plant growth may require two sequential applications of a desiccant to prepare the field adequately for harvest. Unlike the windrow curing process, immature green pods that come in contact with the desiccant will not develop viable seed. It is important that residual soil moisture be utilized prior to desiccation or the plant will continue to regrow from the crown, interfering with harvest. When the plants are dry, the standing crop can be directly harvested using a combine.

Harvest Technique

Harvest begins when seeds are mature and pods and plant material are thoroughly dried. A standard combine is used to pick up the crop in the windrow, or harvest the whole plant standing in the field and thresh the seed from the pod. To minimize the loss of seed, properly adjusted lifter guards should be used in row-planted stands. A short, vertical cutter bar attached to one side of the platform or header also helps reduce header losses by cutting through foliage and avoiding tearing pods from the stems. A reel is considered necessary only in very light seed crops. All equipment must be carefully adjusted to achieve separation of the very small alfalfa seeds from a large amount of plant material without damaging them. Damaged seed will not germinate. Losses during harvest depend on a number of factors, such as field conditions, crop conditions, machine adjustments, and operation. To minimize seed losses and obtain high-quality seed, machine adjustments and operation must match the field and crop conditions. The seed is transferred from the combine into boxes on trucks and is then taken to the conditioning facility for cleaning and bagging.

Seed Conditioning

Conditioning removes soil, weed seeds, and other debris from the alfalfa seed. This is accomplished by equipment that uses differences in physical characteristics of alfalfa seed and the nonseed fraction, such as particle size, shape, density, and surface texture. Separating machines include (1) air-screen cleaners, (2) specific gravity separators, (3) velvet roll seed separators, and (4) magnetic separators. All equipment is thoroughly cleaned between seed lots.

When a high hard-seed percentage occurs, a process called scarification is performed to lower the hard-seed content. Seed can be scarified by chemically or mechanically scratching the seed coat to allow for moisture penetration. Generally, this is not required for seed of nondormant varieties; however, dormant varieties have a higher hard-seed percentage, and scarification improves germination of those lots.

All seed lots are tested for purity, germination, and noxious weed content before marketing.

Crop Residue Management

Crop residue following harvest (straw, chaff, and shattered seed) must be managed to eliminate overwintering sites for alfalfa insect pests and prepare the field for subsequent production. Typically, the combine leaves the straw in windrows. Following harvest, the straw is chopped and scattered throughout the field. Subsequent cultivation followed by irrigation facilitates the decomposition process. In some cases, growers may burn the residue in the field. Years ago, the residue was baled and removed, or grazing sheep were brought in to clean up the debris, but many of the currently registered chemicals for pest control and desiccation restrict treated plant material from entering the food chain.

Volunteer alfalfa that germinates and emerges from seed dropped during harvest must be controlled to maintain the genetic characteristics of the variety and also to reduce populations of alfalfa seed chalcid. Irrigating the field following harvest will aid in germinating good seed or rotting the chalcid-infested seed. Volunteer alfalfa and any weeds that emerge may be controlled by cultivation and/or chemical treatments.

In some areas, the regrowth following harvest may be taken as a forage cutting either in fall or spring. Removal of the regrowth improves the efficacy of soil-active herbicides, helps control some insect pests, brings income to the grower, and allows for optimum timing of the crop production season.

Seed Certification

Typically, about 60 percent of the alfalfa seed produced in California is certified. Certification is required for export, and highly recommended for domestic use. Certified alfalfa seed production requires that the grower meet specific standards, regulated by state and federal seed-certifying agencies. Inspectors from the state Crop Improvement Association look at each field at least once during the growing season to make sure it meets the requirements for certification.

Before establishing a new stand of alfalfa for seed production, the proximity to adjacent alfalfa fields should be taken into consideration. Isolation requirements for certified seed production are based on the size of the certified field and the percentage of the field within 165 feet of another variety of alfalfa. If 10 percent or less of the certified field is within the 165-foot isolation zone, no isolation is required. If more than 10 percent of the field is within the isolation zone, that part of the field must not be harvested as certified seed. This requirement is based on the assumption that seed from the entire field will be mechanically mixed during harvest and cleaning operations, and in this process will dilute the small percentage of off-type seed that may be produced in the area closest to adjacent fields of different varieties. With the recent introduction of genetically modified alfalfa varieties, isolation standards are being reviewed to make sure they result in acceptable levels of adventitious presence, since some markets are sensitive to genetically-modified traits.

Fields must be free from prohibited noxious weeds, and sweet clover may not exceed 10 plants per acre. Restricted noxious weeds must be controlled, and any such infestation (including common weeds that are difficult to separate, such as dodder and Johnsongrass) will be described on the field inspection report. Every field should be rogued to remove any plants of another crop or variety. Some noxious weeds that must be controlled are Russian knapweed (*Acroptilon repens* [L.] DC), white horsenettle (*Solanum elaeagnifolium* Cav.), alkali mallow (*Malvella leprosa* [Ortega] Krapov), and field bindweed (*Convolvulus arvensis* L.).

Fields may be refused certification due to poor growth, poor stand, disease, insect damage, and/or any other condition that prevents accurate inspection or creates doubt as to the identity of the variety.

Additional Reading

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Publication 8308
ISBN-13: 978-1-60107-552-9

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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.

5/08-WFS