# PRODUCING QUALITY ALFALFA SEED FOR THE FORAGE INDUSTRY

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## ABSTRACT

Alfalfa seed is produced in the Western United States in a specialized process. Production practices are tailored to the specific climatic conditions in each growing region. Irrigation must be carefully controlled to stress the plants to encourage flowering and seed production. Weed control is essential to meet the requirements for purity demanded by the industry. Insect pests, especially lygus bugs, are managed throughout the season, using strategies that protect pollinators, which include honey bees, leafcutting bees, and alkali bees. Fields are desiccated and harvested in the fall. Once seed is conditioned and tested, it is available to meet the demand for high quality seed from forage producers throughout the world.

**Key Words: seed production, clipback, dodder, pollination, desiccation, conditioning**

## INTRODUCTION

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, and sheep. A very small fraction of the total production is used by the sprout industry. This article provides an overview of alfalfa seed production techniques from the Western United States where the climate is ideal for production of high-quality alfalfa seed. A chapter in the recently published *Irrigated Alfalfa Management for Mediterranean and Desert Zones* covers alfalfa seed production practices in California in detail and can be found by following the links at http://alfalfa.ucdavis.edu.

## 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. 1). Eighty-five percent of that total is produced in the five western states - California, Idaho, Oregon, Washington, and Nevada. The balance of the seed comes primarily from Arizona, Utah, Montana, and Wyoming. 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. As acreage decreased in California, expansion in Idaho and other northwestern states maintained U.S. supplies at a nearly constant level. Production per acre has been fairly steady within a given seed-producing region. 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.

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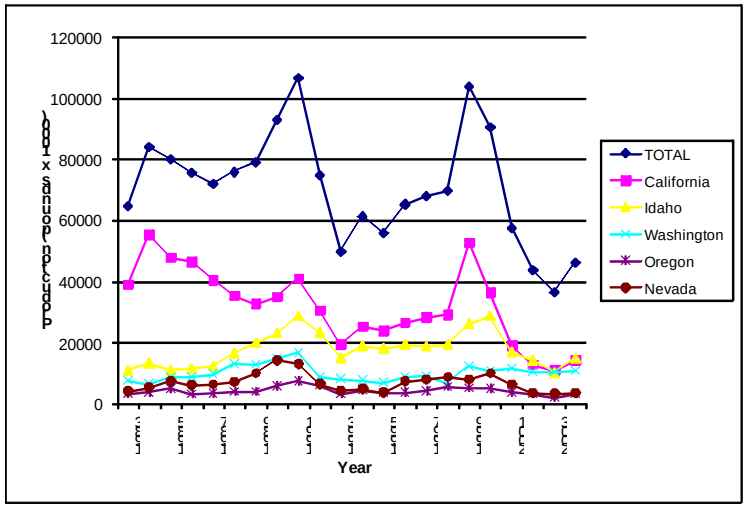


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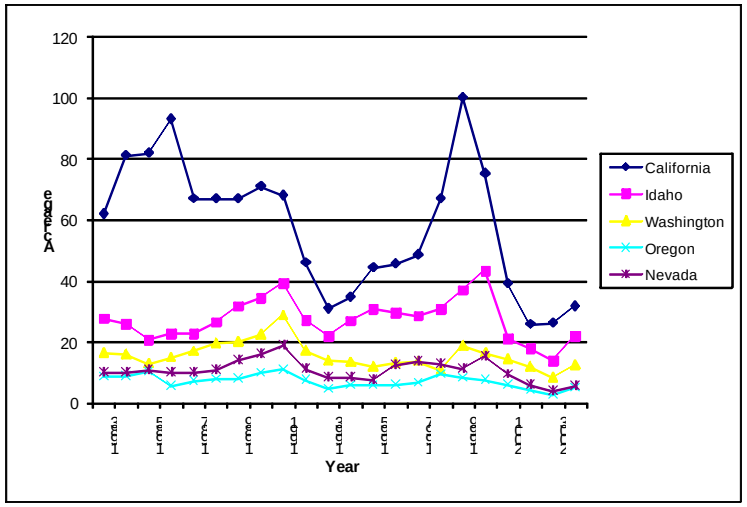


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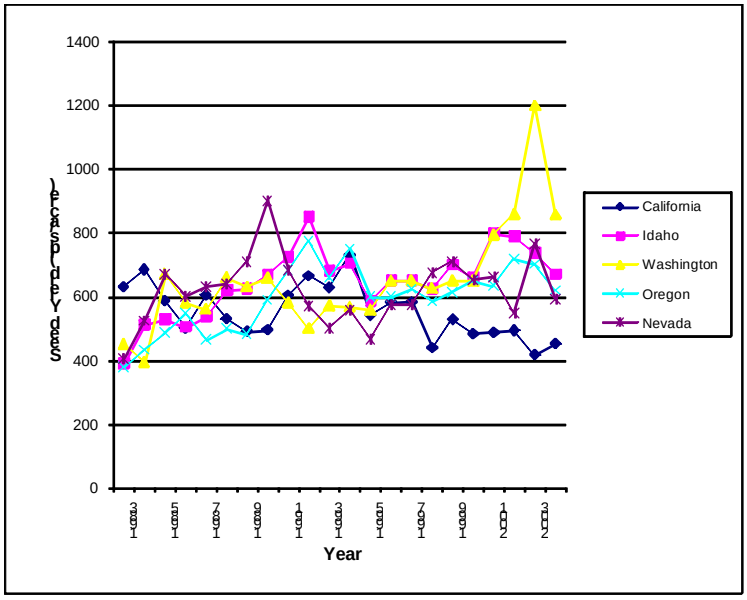


Figure 1. Alfalfa seed (a) production, (b) acreage, and (c) yield per acre for the five western states.

## 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. 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 from the surface) if special care is taken with respect to irrigation and field management.

### *Time of Seeding*

The majority of seed alfalfa stands are established in the late summer or early fall. The recommended planting dates are generally the same as for alfalfa forage production; however, growers are often forced by constraints of their crop rotations to schedule later planting dates. If planting takes place during the winter months, alfalfa seed germinates and emerges slowly, giving winter weeds a competitive advantage, thereby hampering stand establishment. Spring 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, including application of preplant or preemergence herbicides.

### *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. 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, age of stand, 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 (20-30 inches [51-76 cm]) used when smaller plants are produced.

### *Plant Population (Seeding Rate)*

The density of plants in the entire field, or within an individual row, has been shown to directly affect 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.

### *Seeding Methods*

When planting, seed depth should not exceed 0.5 inch (1.3 cm). 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. 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.

## CULTURAL PRACTICES

### *Clipback*

Once the stand is established, fields are often clipped in the spring 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 purpose of ‘clipback’, also known as ‘setback’, is to encourage plants to come into bloom uniformly and to synchronize bloom with the period in the season when pollinators are most active. 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.

Following clipback, regrowth is initiated and the plant blooms approximately 35 to 45 days later. Properly timed and uniformly scheduled within an area, clipback in parts of California 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. Most researchers have been unable to detect increases in seed yield as a result of soil or foliar applications of fertilizer containing both major and minor elements.

### *Supplying Water*

Both the timing and amount of water applied can greatly affect the condition of the field and subsequent seed 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. 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. Irrigation must be properly timed during bloom 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, especially in the Pacific Northwest. Drip irrigation systems are rare in alfalfa seed fields.

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.

## 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 prevent weed seeds from contaminating the crop seed. 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*, *C. campestris* and *C. planiflora*) can be a particularly troublesome weed in alfalfa seed fields. 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. There are effective pre-emergence herbicides registered to control dodder, however, seed continues to germinate throughout the season, when residual activity of herbicides declines. Some newer herbicides have post-attachment activity, but often growers resort to spot burning, or clipping and carrying dodder-infested plants out of the field, to control late-emerging dodder. Often, the alfalfa is killed in an area during the dodder control process, giving weeds a greater opportunity to encroach.

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 re-cleaning 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* Gussakovsky). Occasionally stink bugs (*Chlorochroa sayi* Stal and *Euschistus conspersus* Uhler) and armyworms (*Spodoptera* spp.) may require control measures. 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 (*Acyrthosiphon pisum* [Harris]), blue alfalfa aphid (*Acyrthosiphon kondoi* Shinji), spotted alfalfa aphid (*Therioaphis maculate* Buckton), cowpea aphid (*Aphis craccivora* Koch), and several species of Lepidoptera that occur in summer and fall. In nondormant alfalfa varieties, host plant resistance has 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. Efforts are underway to develop germplasm with resistance to lygus bug feeding.

Beneficial insects in alfalfa seed fields include minute pirate bugs (*Orius* spp.), big-eyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.), and lacewings (primarily *Chrysopa* 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, a pre-bloom insecticide is applied in spring before bees are placed in the seed field. During bloom, 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 pollinators, 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 must be made to determine if bees are on the outside of the colony boxes or shelters before applying insecticides in an area. The condition of pollinator populations, 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.

### *Insect Management Strategies*

There are a limited number of biological, cultural, and chemical control options for managing insect pest populations in seed alfalfa fields. 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 management** is of limited effectiveness in controlling most pests in alfalfa seed fields. 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** 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 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.

## 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* F.), and alkali bees (*Nomia melanderi* Ck11.). 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.

### *Honey bees*

In California, most alfalfa seed producers use honey bees (*Apis 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 pollinators used in other seed producing states.

### *Leafcutting Bees*

Growers in the Pacific Northwest rely on alfalfa leafcutting bees (*Megachile rotundata* F.) for seed pollination. Many growers in California have also 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 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 of bees (10,000 bees per gallon) 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 most 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 (*Nomia melanderi*), which are solitary, soil-nesting bees. Bee beds (nesting sites) are difficult to manage in many cropping systems and, as a consequence, alkali bees are not used for commercial pollination in most areas.

## DESICCATION 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, a swather cuts the alfalfa and lays it in windrows on the stubble to air dry in the field. 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.

### *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. 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.

### *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. 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. 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 non-seed fraction, such as particle size, shape, density, and surface texture. 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. 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. In some states, growers are still able to burn field residues, but air quality restrictions in other areas prevent this.

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

Seed 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 proximity of the field to another variety of alfalfa. 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*), white horsenettle (*Solanum elaeagnifolium*), alkali mallow (*Malvella leprosa*), and field bindweed (*Convolvulus arvensis*).

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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