Alfalfa Stand Establishment

Shannon C. Mueller
Farm Advisor, University of California Cooperative Extension, Fresno, CA

Carol A. Frate
Farm Advisor, University of California Cooperative Extension, Tulare, CA

Marsha Campbell Mathews
Farm Advisor, University of California Cooperative Extension, Modesto, CA

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Chapter 4

Corresponding Author:
Shannon C. Mueller
(scmueller@ucdavis.edu)

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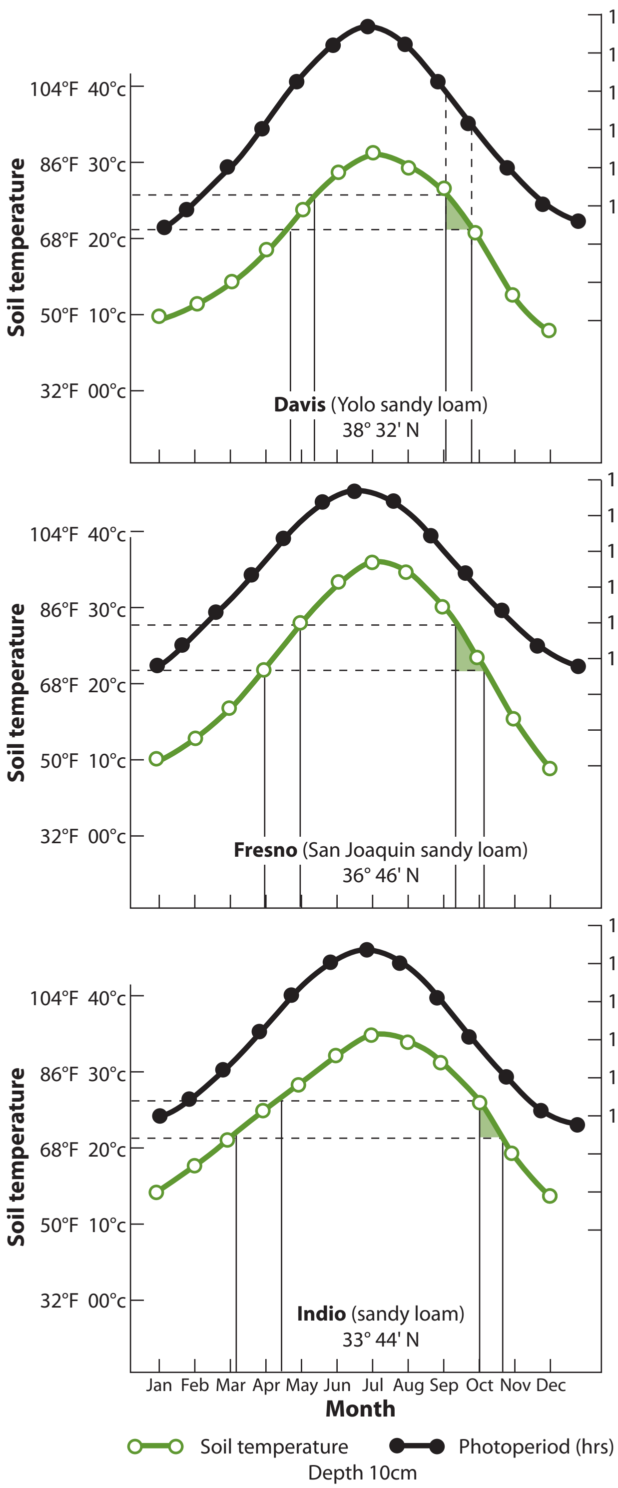
Seedling establishment is a critical phase in the life of an alfalfa stand, impacting production for many years. Time spent planning and preparing for stand establishment pays off in many ways, resulting in a dense, vigorous stand that produces high-quality, high-yielding alfalfa throughout the life of the stand. If a stand fails to establish, replanting requires additional time and expense. Furthermore, reworking the seedbed often delays planting beyond the optimum time, and options for alternative crops that may take the place of alfalfa become limited. On the other hand, accepting a marginal stand could result in lower yield potential, shorter stand life, weed pressure, and reductions in forage quality.

Optimum Environmental Conditions for Stand Establishment

Temperature and photoperiod (day length) influence alfalfa seedling development. They influence growth rate, stem initiation, and the allocation of photosynthates to the development of roots and stems. Using weather records from a given area and information regarding the response of alfalfa seedlings to temperature

FIGURE. 4.1

Predicted optimum dates of planting for Davis, Fresno, and Indio, California, based on average monthly photoperiod and soil temperature.



and photoperiod, the optimum time to plant alfalfa can be predicted. If the alfalfa plant is given as close to optimum conditions for development as possible, the risk of stand failure declines.

Historically, growers in Mediterranean and desert zones, such as California's Central and Imperial Valleys, have planted alfalfa in late fall through early spring to take advantage of winter and spring rainfall for germination. Although the chance for rainfall is greater during this period, the weather is often cold, slowing alfalfa seedling growth and allowing winter weeds to compete heavily with the alfalfa, reducing the chance of successful stand establishment. During prolonged periods of cool temperatures and high humidity common during this period, diseases, such as Sclerotinia stem and crown rot (*Sclerotinia* spp.), may also harm seedling stands. Planting dates are also restricted by crop rotations. Crops such as cotton, harvested in late fall, force growers to delay planting until November, December, or January, when cotton residue can be destroyed and alfalfa seedbeds prepared.

Optimum Conditions for Germination

Alfalfa seed germinates best at soil temperatures from 65° to 85°F (18°–29°C). When the soil temperature is 40°F (4°C), it takes alfalfa six days to germinate, but germination takes only two days at 65°F (18°C). Larry Teuber at UC Davis evaluated alfalfa seedling growth and development in response to variations in temperature and photoperiod (Fig. 4.1). The optimum temperature for root growth during the first month was 69°–76°F (21°–24°C), depending on dormancy class. Shoot growth is optimum at temperatures ranging from 72° to 76°F (22°–24°C). Alfalfa stops growing when the air temperature drops below 42°–34°F (6°–1°C), depending on the variety. In the Central Valley, optimum temperatures for alfalfa shoot growth occur from mid-September through early October, and from late April to early May. In California's desert regions, warm conditions extend later in the fall and begin earlier in the spring. The risks of late-fall or winter plantings are much lower in these desert areas than in the higher rainfall and cooler areas of the Central Valley.

Cultivar Interactions

Not all cultivars respond in the same way to environmental conditions. Photoperiod influences alfalfa growth and development to varying degrees, depending on the dormancy class of the cultivar. The effect of photoperiod is less than that of temperature in cultivars grown throughout California. However, there are two major growth characteristics influenced by photoperiod: (1) initiation of crown buds and stems, and (2) allocation of photosynthates to the roots. Photoperiods longer than 12 hours favor shoot development, whereas photoperiods shorter than 12 hours promote root growth. This information was combined with temperature response data to identify optimum planting dates for several locations throughout California. For arid climates similar to the Central Valley, fall planting dates from September 15 to October 31 and spring planting dates from February 1 to March 15 have the greatest potential for successful stand establishment.

Planting Dates

Several replicated field trials have confirmed the recommended planting dates for the Central Valley. In a Sacramento Valley trial conducted on cracking clay loam soils, data showed a yield advantage of almost 4 tons per acre (9.0 Mg ha^{-1}) the first season for a September planting compared to a March planting. October and November plantings, although better than the March planting, did not yield as high as the mid-September planting. The early planting yield advantage carried over into the second season (Table 4.1). In a second study (Table 4.1), the September planting emerged rapidly, resulting in an excellent stand, and yield advantages over later plantings were even more pronounced than in the previous trial. The September planting yielded almost 9 tons (8.2 Mg) in the first season, compared with only 4.1 tons (3.7 Mg) from the spring planting. In the second year after establishment, yields were equivalent for all planting dates. When production for the two years is combined, the September planting produced 2.7 more tons per acre (6.0 Mg ha^{-1}) than the November planting, and 4.6 more tons per acre (10.2 Mg ha^{-1}) than the March planting.

Planting in the fall (Sept.–Oct.) produces 20-30 percent higher yields the first year than spring planting.

A similar study was conducted in the southern Central Valley (western Fresno County, Panoche clay loam soil). There was a 1-ton (0.9-Mg) yield advantage for a September planting, compared to a November planting the first year, and a 3-ton

TABLE 4.1

First and second year yield data for planting date trials, Yolo County, Sacramento Valley, California, 1977–1978 and 1978–1979

Planting Date	Yield, Tons per Acre* (90% Dry Matter)			Total No. of Cuttings for Two Years
1977–1978	**First Year**	**Second Year**	**Total**	
14 Sept.	8.1[a†]	9.1[a]	17.2[a]	11
17 Oct.	7.3[b]	8.8[a]	16.0[b]	11
16 Nov.	6.2[c]	8.3[b]	14.5[c]	10
21 Mar.	4.4[d]	8.1[b]	12.6[d]	9
LSD (0.05)	0.57	0.43	0.88	
1978–1979	**First Year**	**Second Year**	**Total**	
22 Sept.	8.9[a]	8.3	17.2	11
24 Oct.	6.1[b]	9.9	16.0	11
27 Nov.	5.7[c]	8.8	14.5	10
14 Mar.	4.1[c]	8.5	12.6	9
LSD (0.05)	0.42	NA	NA	

[†]Within a column, means followed by the same letter are not significantly different at the 5 percent level of probability. Comparisons are valid only within individual years, not between years.

NA: statistical information was not provided in the reference source for the table.

*To convert tons per acre to Mg ha^{-1}, multiply by 2.24.

(2.7-Mg) yield advantage for a September planting, compared to either a December or April planting. The advantage of early fall planting continued through the second production year. Combining yields from the first two years, the September planting produced 4.5 tons per acre (10.1 Mg ha^{-1}) more than either the December or April plantings. It also yielded over 2 tons per acre (4.5 Mg ha^{-1}) more for the combined two years than the November planting date (Table 4.2).

In another trial in the southern Central Valley (Fresno County, Hanford sandy loam soil), an October planting produced 0.7 tons per acre (1.6 Mg ha^{-1}) more than a November planting and 4 tons per acre (9.0 Mg ha^{-1}) more than a February planting (Table 4.3). These data support September and early October as optimum times for establishing an alfalfa stand in the Central Valley. Planting in the fall gives 20–30 percent higher yields the first year, compared to spring planting. This response often persists into the second year as a result of increased vigor and a longer growth period before the first cutting. Planting date restrictions are less in California's Low Desert Regions, because winter conditions are milder, but advantages are also seen with October plantings, compared to planting under midwinter conditions.

Practical Considerations

There are challenges when planting alfalfa in September. The biggest hurdle is providing moisture to the seed at a time of year when rain is not expected. This can be achieved by pre-irrigating and planting to moisture (assuring that moisture is present at seeding depth) or by irrigating after planting using sprinklers or surface irrigation systems. In addition, September plantings result in a larger canopy in December and January, which retains moisture and humidity and favors Sclerotinia stem and crown rot disease. Egyptian alfalfa weevil, *Hypera brunneipennis* (Gyllenhal), often infests early-planted fields, resulting in the need to spray in March, which is not typical for seedling fields planted in November or later.

There are examples of stands successfully established outside the recommended planting dates; however, the risk of failure is greater. More consistent results are achieved when research-based recommendations are followed. When following cotton that is picked late, the ground is often too wet to be worked. As planting is delayed, there is a danger that frost will kill the developing seedlings, or win-

TABLE 4.2

First and second year yield data for planting date trial, West Side Research and Extension Center, Fresno County, San Joaquin Valley, California, 1979–1981

Planting Date	Yield, Tons per Acre* (90% Dry Matter)		
	First Year (1980)	Second Year (1981)	Total
18 Sept.	7.4[a†]	7.5[a]	14.9
14 Nov.	6.4[b]	6.5[b]	12.9
13 Dec.	4.6[c]	6.1[b]	10.7
11 Apr.	4.5[c]	6.3[b]	10.8
28 May	3.0[d]	6.2[b]	9.2
LSD (0.05)	0.72	0.61	NA

†Within a column, means followed by the same letter are not significantly different at the 5 percent level of probability. Comparisons are valid only within individual years, not between years.

NA: statistical information was not provided in the reference source for the table.

*To convert tons per acre to Mg ha-1, multiply by 2.24.

TABLE 4.3

Alfalfa planting date study, Fresno County, southern Central Valley (Hanford sandy loam soil), California, 1988–1989

Planting Date	First Year Yield, Tons per Acre* (90% Dry Matter)	No. of Cuts
12 Oct.	13.3[a†]	7
7 Nov.	12.6[b]	7
23 Feb.	9.3[c]	6
LSD (0.05)	0.63	

†Means followed by the same letter are not significantly different at the 5 percent level of probability.

*To convert tons per acre to Mg ha^{-1}, multiply by 2.24.

ter weeds will out-compete the alfalfa. Under such conditions, delaying planting until spring may be more desirable. Alternatively, planting a winter cereal after cotton followed by an early-maturing summer annual crop and delaying alfalfa planting by one year may be a better strategy than seeding under sub-optimal conditions.

Benefits of Early Fall Stand Establishment

- More rapid germination resulting from warmer temperatures.
- Increased vigor and ability of alfalfa seedlings to compete with winter weeds.
- Development of a deeper, more vigorous root system.
- Higher yields that may persist into future production years.
- Yield advantages from early fall plantings may offset the cost of renting sprinklers.
- Alfalfa seedlings from September plantings can withstand herbicide applications.
- The weather in September and October is more predictable than later fall or winter.

Seedbed Preparation

To plant during the recommended period, growers must prepare seedbeds in advance and have the ability to provide moisture to germinate seed and maintain seedling growth. This is often one of the greatest barriers to adoption of recommended early fall planting dates. Proper field preparation before planting is crucial because the stand will be intensively managed and harvested for 3 to 5 years, or longer. Planning and preparing properly for stand establishment may reduce future weed and disease problems, promote water-use efficiency, and result in higher yield and longer stand life.

Surveying the Site

Following destruction of residues from the previous crop, soil samples should be taken to determine fertility status and pH so that necessary amendments can be incorporated during seedbed preparation. Knowledge of previous weed problems is also important for determining the need for herbicides. A strategy for controlling weeds should be developed as the site is prepared. Weeds compete with alfalfa for light, water, and nutrients, and, if not controlled, reduce nutritional value of the forage. They can reduce seedling vigor and in some cases reduce alfalfa plant density to such a degree that the field has to be replanted. Preplant irrigation and cultivation can eliminate some weeds, but herbicides may also be needed. See Chapter 6, "Alfalfa Fertilization Strategies," for more detailed information on soil fertility and Chapter 8, "Weed Management," for weed management information.

Alfalfa performs best on well-drained, relatively deep soils, with a minimum rooting depth of 3–4 feet.

Alfalfa performs best on well-drained, relatively deep soils with a minimum rooting depth of 3–4 feet (0.9–1.2 m). Limitations to rooting depth may be caused by physical or chemical factors, such as hardpans, stratified soils, or salts, that restrict productivity and lower yield. Poor drainage or high water tables may also limit root growth. Hardpans exist naturally in some soils, whereas restrictions known as plow pans are created by agricultural practices that promote compaction. These practices include working wet soils, driving equipment over moist or freshly cultivated soils, increasing equipment weight to apply more power or traction, and repeated cultivation of dry soils to make a smoother seedbed. Whether compaction becomes a limiting factor in plant growth depends on how it directly affects water percolation, aeration, and root extension, and indirectly affects nutrient uptake, plant diseases, and growth rate. The serious effects of soil compaction are usually found between the surface and 18 inches (45.7 cm) deep, but in some cases the effect can be found as deep as 24 inches (61.0 cm).

Stratified, or naturally layered, soils occur when there are textural differences within a soil profile (e.g., layers of sand within a loam or clay loam soil, or clay layers within a sandy loam soil). Restrictive layers are usually found deep within the soil profile, deeper than those created by compaction, so they are more difficult to correct by tillage. Using a backhoe to evaluate the distribution of roots in a soil profile will assist in determining whether soil layering or compaction problems exist in a field. See Chapter 2, "Choosing Appropriate Sites," for a better understanding of the limitations of different sites.

Deep Tillage

Layered or compacted soils respond to mixing by deep plowing, ripping, or other tillage operations to create a soil profile with more uniform texture (Fig. 4.2). Deep tillage breaks up compacted or dense layers in the soil. It increases infiltration rate, fractures stratified layers, mixes the soil profile, and reduces bulk density and soil strength. Rooting depth is often improved with deep tillage where there are subsurface impediments. The cost of deep tillage versus its potential benefits must be carefully evaluated because economic returns are difficult to predict. The cost of deep tillage varies, depending on the horsepower requirement and desired depth of tillage, and the results are often not easy to see. It takes a significant yield increase to recover the cost of deep tillage and it is not well understood how long the effects of deep tillage last.

Tools for deep tillage include large moldboard and disc plows, rippers, and chisels. Rippers and chisels come in a wide variety of sizes and shapes. Curved shanks require less draft than straight shanks to loosen the same amount of soil. Soil moisture content, depth, and spacing of ripper shanks influence the outcome. Rippers pull more easily through moist soils, but do a less effective job than when the operation is performed on dry soils. Ripping is most effective when shanks are spaced no more than 3 feet (0.9 m) apart. Shank spacing should be equal to or less than the depth of ripping. Ripping never breaks the soil straight across between the points of adjacent shanks. Ripping in one direction with closely spaced shanks results in more of the soil being shattered than

FIGURE 4.2

Deep tillage is frequently performed on heavy soils with subsurface impediments.

does ripping in two directions with widely spaced shanks.

Depending on soil type and crop rotation, ripping before establishment of each alfalfa stand should be adequate. Fields can be ripped in the fall prior to a spring or subsequent fall seeding of alfalfa.

Plowing and Conventional Tillage

Ripping shatters compacted layers, but does not mix the soil, so the beneficial effects of ripping may be short-lived in layered soils. Deep plowing with moldboard or disc plows is particularly effective in layered soils because plowing inverts and mixes stratified layers. Plows move all of the soil to a depth of 18–30 inches (45.7–76.2 cm) depending on the size of the equipment. Plows have the potential to loosen compaction, providing the moisture content is such that the soil will crumble rather than form into clods. If deeper mixing is desired, a slip plow can be used to reach 5 or 6 feet (1.5–1.8 m) deep. Slip plowing displaces and cracks more soil than does ripping, but requires correspondingly higher energy inputs. However, a slip plow only mixes the soil in the trench it makes, so the mixing job is not as thorough as that of moldboard or disc plows. Slip plowing followed by moldboard or disc plowing, rather than either operation alone, gives the best chance of achieving the desired results. Soils require extra time, tillage, or irrigation to firm up or settle after plowing. If possible, freshly plowed soil should not be disturbed for several weeks to avoid re-compaction.

Even if it is determined that deep tillage is not necessary, ripping to moderate depths (20–32 inches [50.8–81.3 cm]) is usually cost effective and recommended to reduce compaction from agricultural operations in preceding crops. Although less expensive to rectify, soils compacted by field equipment must be dealt with repeatedly because farming practices rather quickly re-compact soil that has been loosened by tillage.

Land Leveling

Once deep tillage and plowing operations are complete, the field should be disked and planed. Leveling fields to be planted to alfalfa is extremely important because water must flow evenly over the flat surface. With flood irrigation systems, laser leveling is usually recommended to prepare the field. Laser leveling should be a two-step process. The field is first leveled following any necessary deep tillage operation. Then, once the irrigation borders are established, the area between them should be leveled and a uniform slope achieved. The final smoothing of the field is usually achieved with a land plane to remove any minor irregularities in the soil surface (Fig. 4.3). Eliminating high and low spots in the field will improve the efficiency of the irrigation system and prevent harvest problems. Depending on the rotation, laser leveling the field may not be necessary each time an alfalfa stand is established. However, touching up the level and slope between borders is always recommended.

Leveling fields for alfalfa is extremely important because water must flow evenly over the flat surface.

FIGURE 4.3

Land leveling to *eliminate high and low spots* is critical to long-term success of surface irrigation.

Checks and Borders

Levees used with border irrigation serve to guide the water as it moves down-slope through the field (Fig. 4.4). Most levees are about 2–4 feet (0.6–1.2 m) wide and 6–8 inches (15.2–20.3 cm) high. These dimensions allow for easy passage of equipment across the border and maximum use of space for alfalfa production. The tops of the levees only need to be a few inches above the water surface while irrigation takes place. Because an alfalfa planting is kept for several years, great care should be taken in constructing the levees so that a level surface the full width of the area between adjacent levees (the check) is maintained. Using cross-checkers, which strip soil from the full width of the check and deposit it along a line to make levees, is recommended. After the soil has been deposited for the levee, a shaper is used to achieve the desired uniform cross-section. The width between the levees ranges from 15 to 20 feet (4.5–6.1 m) on the narrow side, to 50–100 feet (15.2–30.5 m) or more, and should be based on soil type, slope, length of the checks, and flow rate of water available for irrigating the field. Width of harvesting equipment should be taken into consideration in determining the width of irrigation checks. For example, the width of the check should be some multiple of the width of the swather header. See Chapter 7, "Irrigating Alfalfa," for more detailed information about designing and installing an irrigation system.

FIGURE 4.4

Border-check irrigation systems are the most commonly used in California.

The Seedbed

Planting on the Flat

After levees are constructed, the checks are generally floated with a drag scraper to prepare a smooth seedbed for planting that is sufficiently firm to provide good seed-to-soil contact such that seeds absorb moisture and don't dry out. A grower might use a spring tooth harrow to fluff up the seedbed, or a ring roller or cultipacker to pack it down in preparation for seeding, or both. The final seedbed should be fine, firm, and perfectly leveled, with very small (grape-size or smaller) clods. On some silty-clay soil types, golf-ball-size clods are acceptable and melt over the seed during irrigation. Use of press wheels or rolling after seeding may help assure seed-to-soil contact on many soil types. Excessive tillage to create extremely fine seedbeds may lead to crusting after irrigation or heavy rains. Measuring the depth of a footprint left in the prepared seedbed can help a grower assess firmness. If the heel print is greater than ½ inch (1.3 cm) deep, the seedbed is too fluffy and stand establishment may be negatively affected. Sandy soils can tolerate more than ½ inch of fluffy conditions than heavier soils.

The final seedbed should be fine, firm, and perfectly leveled, with very small (grape-size or smaller) clods.

"Bedded" or "Corrugated" Alfalfa

On heavy, poorly drained soils, seed may be planted on beds or corrugations (Fig. 4.5). Although more expensive to prepare, seed planted in this way enables alfalfa production on soils that otherwise would present severe limitations. This practice is not advantageous on well-drained soils. Corrugated planting is a modification of bed planting with lower beds (shallower furrows). Corrugated or bedded alfalfa is a common practice in limited areas of the western United States. With corrugated alfalfa, the crop is furrow-irrigated rather than flooded on flat surfaces using bordered checks. Bedding improves water drainage, thus protecting the alfalfa crown and roots. Furrows move excess water out of the field, which prevents flooding. Although common in the northern Central Valley and Imperial Valley on heavy soils, this approach is rarely used in the southern Central Valley.

Many growers use a 40–60 inch (1.0–1.5 m) bed with 4–6-inch (10.2–15.2 cm) deep furrows, but beds 21 inches (about 0.5 m) wide with deeper furrows are sometimes used on heavier soils. The furrows are sometimes seeded and sometimes not, depending on depth (smaller corrugations are seeded, whereas deep furrows in the bedded fields are kept clean). With deep furrows in bedded alfalfa, equipment must be modified so that the wheels run only in the furrow. When the alfalfa beds are kept low, swathers, rakes, tractors, balers, and harrow-beds have no difficulty traversing the field. Bed width is critical. If beds are too wide, water may not move by capillary action (sub) to the center during irrigation. In soils with elevated salt levels, seedling emergence in the center of the bed may be a problem as salts move with the water front and concentrate there. If gaps between beds are too wide, the chance of having weed problems increases. Another factor influencing bed width is the duration of an irrigation set required to sub across the bed. If the time required to wet the soil to the center of the bed is too long, many of the advantages of a bedding system are lost.

Beds usually start about 20 feet (6.1 m) into the field when irrigating from a fixed head ditch. A border levee from the ditch to the beginning of the corrugation should be developed at intervals suited to the particular field. A similar area should be created at the end of the field, but borders may not be necessary. The area should allow for two swather passes at the top and bottom ends of the field. Equipment can turn in this area without crossing the furrows. The border levee at the top end will guide the water to the furrows.

An advantage to this system is that plants can be easily irrigated up during stand establishment. After planting, water is trickled down the furrows and allowed to sub across the beds from both sides. A slow irrigation of this kind can provide the moisture needed for germination and early root development during the fall and spring months. Another advantage is that hay may cure more quickly because of increased airflow beneath the windrow.

FIGURE 4.5

Bedded or corrugated alfalfa in the Sacramento Valley, California. Beds range from 24″-60″, and furrows range from shallow to 8-10″ deep.

Seeding Rates

Seeding rates vary with seed characteristics, soil type, climate, seedbed condition, and method of planting. There are approximately 220,000 alfalfa seeds per pound (454 g) of raw seed. If distribution was perfectly uniform and every seed germinated and emerged, a 20 pound per acre (22.4 kg ha^{-1}) seeding rate would result in 100 plants per square foot (0.09 m^2), far more than is typically observed in a newly seeded stand. Numerous factors reduce the actual alfalfa emergence, including poor seedbed conditions, seeding depth control, insufficient or excessive moisture, poor seed germination, seedling diseases, and inclement weather. Therefore, a seeding rate of 20–25 pounds per acre (22–28 kg ha^{-1}) broadcast or 15–20 pounds per acre (17–22 kg ha^{-1}) drilled typically results in 20–50 plants per square foot (0.09 m^2) one month after seeding, which is considered an adequate stand. Higher seeding rates may be justified if the seedbed is rough, the seed is planted late, the seed is broadcast rather than drilled, alkalinity and salinity are problems, or moisture conditions are marginal. Usually it is better to correct these problems rather than to increase the seeding rate to compensate for poor planting conditions.

At the end of the first season, about 40–50 percent of the plants typically remain. Higher seeding rates generally do not result in improved yield or alfalfa stand density except under the poorest of seedbed conditions. A natural thinning process takes place so that, although a stand may be thicker initially, there is no difference in plant density after the first year of production. Lower plant populations have higher survival rates, resulting in the same final plant population achieved with higher seeding rates (Table 4.4).

Seed Treatment

Seed may be coated or treated for a variety of reasons. One of the simplest reasons is to extend short seed supplies; in that case, the seed is coated with an inert material. Although the number of pounds of planting material may be the same, when using coated seed, approximately one-third fewer seeds will actually be planted because of the weight of the coating (seed coatings are typically about 33 % of the total seed weight). More often, coatings are used to provide fungicide or *Rhizobium* bacteria in close proximity to the seed to enhance seedling survival and development. Potential benefits from coating seed include:

- quick sprouting and more effective establishment of seedling populations
- improved performance of *Rhizobium* bacteria
- protection of seed from insects and disease organisms
- incorporation of growth factors, fertilizers, micronutrients, and pesticides

However, positive benefits in favor of seed coatings have not been observed consistently in research trials. There is a lot of natural variation in soil populations of alfalfa seedling pathogens and in the effect of soil and environmental conditions (e.g., temperature and moisture) on their ability to cause disease. Large losses resulting from disease will occur in some fields, but not in others. Consequently, there are times when seed coated with fungicide confers a distinct advantage, and times when it does not.

In research trials conducted in the Central Valley in 1988–1989, raw and coated seed, treated with or containing a variety of inoculum types and fungicides, were compared.

TABLE 4.4

Effect of seeding rate on alfalfa plant density and yield the first and second year after seeding. West Side Research and Extension Center, Fresno County, San Joaquin Valley, California, 1979–1981.

Seeding Rate (Pounds per Acre*)	1 Month after Planting (Number of plants per ft**)	1 Year after Planting (Number of plants per ft**)	Percent Survival	1980 Yield (Tons dry matter per Acre***)	1981 Yield (Tons dry matter per Acre***)
10	12.7[a†]	8.4[a]	66	5.2	6.3[b]
20	21.9[b]	9.5[ab]	44	5.2	6.5[ab]
30	30.0[c]	10.7[ab]	36	5.2	6.6[a]
40	35.4[d]	11.2[b]	32	5.1	6.6[a]
LSD (0.05)	3.21	2.68		NS	0.17

†Within a column, means followed by the same letter(s) are not significantly different at the 5 percent level of probability.

NS: not significant.

* To convert pounds per acre to kg ha^{-1}, multiply by 1.12.

** To convert number of plants per ft^2 to number per m^2, multiply by 9.29×10^{-2}.

*** To convert tons per acre to Mg ha^{-1}, multiply by 2.24.

Coated seed and raw seed were planted at a rate of 25 pounds per acre (28 kg ha^{-1}) on three planting dates. Initial and final stand counts for the October planting were not significantly different for any of the treatments. Initial stand counts ranged from 34 to 51 plants per square foot (0.09 m^2). Final stand counts ranged from 9 to 15 plants per square foot (0.09 m^2). For the November and late February plantings, initial stand counts were lower for coated seed compared to raw seed, because fewer coated seeds were planted per acre. Adding fungicides or *Rhizobium* inoculum to the seed coating did not provide an advantage in terms of stand establishment. However, with raw seed, Apron fungicide (metalaxyl) increased the initial stand count for the November planting. Within planting dates, by the end of the first production year, all plant populations were comparable. Within harvests and planting dates, there were no significant effects of seed treatment on forage yield. A trial at UC Davis showed similar results.

From our research and experience, seed coatings do not appear to enhance or detract from establishing alfalfa stands. Reduction in the number of seedlings per unit area can result from the fact that fewer seeds per pound are sown with coated seed, but percent survival can be higher than with raw seed (Table 4.5). Although percent survival was higher with coated seed in some treatments, initial stand counts were lower, and there were no differences between any treatments in stand counts at the end of the first year, and no effect on yield. The value of seed treatments with Apron

TABLE 4.5

Effect of seed treatment and planting date on alfalfa seedling survival at three planting dates. Kearney Research and Extension Center, Fresno County, southern Central Valley, California, 1988–1989. All plots seeded at 25 lbs/acre (28 kg ha^{-1})

	Planting Dates					
	12 Oct. 1988		7 Nov. 1988		23 Feb. 1989	
	Percent Survival*					
Seed Treatment	1st Month	Final	1st Month	Final	1st Month	Final
Raw Seed	39.0	10.8	39.4[a†]	12.8[ef]	56.6	14.4[bc]
Raw Seed+Apron	45.6	13.4	51.8[bcd]	14.8d[ef]	57.5	13.1[c]
Raw Seed+p.p. inoc.**	40.1	11.7	48.0[abc]	11.5[f]	51.9	14.1[bc]
Raw Seed+p.p. inoc.+Apron	38.0	11.1	48.9[abc]	13.9[def]	57.8	14.6[bc]
Raw Seed+granular inoculum	41.9	9.9	44.2[ab]	17.3[cde]	51.8	15.7[bc]
Coated Seed	58.2	14.7	58.1[cde]	22.9[a]	58.0	19.3[ab]
Coated Seed+Apron	50.7	14.6	60.2[de]	17.8[bcd]	57.5	21.3[a]
Coated Seed+inoc.	45.4	13.3	47.7[abc]	21.3[abc]	59.7	21.4[a]
Coated Seed+inoc.+Apron	49.9	14.4	58.1[cde]	23.9[a]	61.8	17.6[ab]
Coated Seed+inoc.+Apron+Rovral***	54.3	11.7	63.6[e]	22.3[ab]	70.5	21.6[a]
LSD (0.05)	NS	NS	11.22	4.86	NS	5.24
CV (%)****	31.8	21.7	14.9	18.8	14.0	20.1

[†] Within a column, means followed by the same letter(s) are not significantly different at the 5 percent level of probability.
NS: not significant.
* Percent Survival: number of surviving plants vs. number of seed originally planted. Final evaluation took place on Nov. 7, 1989.
** p.p. inoc.: powdered peat inoculum
*** Rovral: iprodione. This material is not registered for use on alfalfa in California. Check with your local Extension office to determine its status in your area.
**** C.V.: coefficient of variation

or similar fungicides will depend on the degree of disease pressure. Seed treatments should be viewed as a form of "risk management" that may only pay off occasionally, as in an insurance policy. Use of raw seed may be completely acceptable under optimum conditions, but inoculation with *Rhizobium* and treatment with Apron may be appropriate when seeding under suboptimum conditions.

Inoculating Seed

Nitrogen-fixing *Rhizobium meliloti* Dang. bacteria are found in alfalfa root nodules and are capable of fixing from the atmosphere almost all of the nitrogen the alfalfa crop needs. Most fields in California being considered for alfalfa production have a native population of *Rhizobium* bacteria because alfalfa or clover has been grown previously. For those fields, native populations can provide adequate nodulation and nitrogen fixation for the life of the stand. Soils without a recent history (within the past 10 years) of alfalfa may need to be inoculated with strains of alfalfa *Rhizobium* bacteria selected for their effectiveness in nitrogen fixation. Growers may purchase inoculum and apply it to the seed before planting, or as discussed previously, a seed company may have applied the *Rhizobium* bacteria to the seed directly or in a coating. When buying inoculum, be sure the word "alfalfa" is listed on the container and that the seal on the bag has not been broken. Check the expiration date on the inoculum bag and store in a cool, dry place, preferably a refrigerator. If buying pre-inoculated seed, check the date that the seed was inoculated. Seed inoculated 6 months ago or longer should be re-inoculated before planting.

Inoculum should be applied to the seed following the instructions on the package for either the powdered peat or granular types. Poor nodulation may result from low soil pH levels, use of the wrong kind of bacteria, use of inoculum in which the bacteria are dead, or improper application of the bacteria to seed.

Seeding Method

There are essentially two methods used to plant alfalfa: broadcast (by ground or air) and drill. When properly calibrated to achieve the desired seeding rate and a uniform planting depth, and when used in a well-prepared seedbed, successful stands can result from either of these methods. Each has advantages and disadvantages.

Broadcast Seeding. Several types of seeders are commonly used to broadcast seed evenly on the soil surface. A cultipacker seeder (e.g., Brillion seeder) does an excellent job of planting alfalfa because it has a roller in front to firm the soil and a roller following behind the seed drop that covers and presses the seed into the soil at an optimum depth. Air-flow ground applicators can be used to broadcast seed evenly over the soil surface, sometimes along with other operations, such as application of fertilizers. With large acreages, or when soil is too wet to support ground equipment, planting seed by air works well. Planting seed by air may be the least expensive method, but there can be disadvantages. Flying seed on to a field may require more seed, may result in more skips, and there is less control over depth of seeding. With all broadcast methods except the Brillion seeder, seed must be covered after broadcast seeding to maximize germination and emergence. A cultipacker or ring roller is an excellent tool for this purpose. Firming the soil around the seed gives it greater contact with moisture and enhances germination. A spike-toothed harrow usually incorporates seed into the top 3 inches of soil, too deep for optimum emergence, and does not provide the desired seed-to-soil contact; it is therefore not recommended.

Drill Seeding. Grain drills, which place the seed in rows at a uniform depth, can be used successfully to establish alfalfa. Seed typically drops behind a disk opener and is covered by press wheels or a corrugated roller. Better drills have good depth control, which should be carefully adjusted for seeding depth. Drills with poor depth control should not be used. Fertilizers may be placed below the seed at planting, if desired. One disadvantage of drilling versus broadcast seeding is the unplanted space between rows, which provides an open area for weed invasion. Some growers drill in two directions, perpendicular to each other, to reduce the possibility of large skips from planter problems. As with broadcast seeding, the seed must be covered and the soil must be firmed around the seed after planting. This can be accomplished using press wheels attached to the planter, by pulling a cultipacker behind the planter, or in a separate operation with rollers or cultipackers.

The most important, but often ignored, step in the seeding process is calibration of the planter. Manufacturer recommended settings are based on average values, and it is important to check the actual flow of seed through the planter before planting. Planter calibration is time well spent to prevent seeding mistakes. Relying solely on settings recommended by the manufacturer, or using the setting from the previous year, may result in significantly under- or over-applying seed to the field. Alfalfa seed size varies, especially when planting coated versus raw seed. Coated seed flows 5–28 percent faster through common seed metering units than does raw seed at the same planter setting.

Seeding Depth

Recommended seeding depth for most California conditions ranges from 0.25 to 0.50 inch (0.6–1.3 cm), depending on soil type and condition. Seed should not be planted at depths greater than 0.75 inch (1.9 cm). Only 2 percent of seeds planted 2.5 inches (6.0 cm) deep will emerge, but 70 percent will come through when planted 0.25–0.50 inch (0.6–1.3 cm) deep. Seed placement is related to the condition of the seedbed at the time of planting. If the soil surface is powdery or fluffy, seed may be placed too deep for maximum emergence. Seed planted too shallowly or with poor seed-to-soil contact can dry out before germination is complete. Planting depth can be evaluated by looking for seeds on the soil surface after the planter or cultipacker has passed by. Seed is likely to be too deep if there are no seeds visible on the soil surface.

Recommended seeding depth for most California conditions ranges from 0.25 to 0.50 inch (0.6–1.3 cm), depending on soil type and condition.

Irrigation—Providing Moisture for New Stands

There are three options to consider for providing moisture to germinate alfalfa seed: (1) plant prior to anticipated rain, (2) plant and irrigate immediately after seeding, or (3) pre-irrigate and plant to moisture. The value of each strategy will depend on tolerance of risk, soil type, reliability of rainfall, and adherence to recommended times of planting.

Pre-Irrigation

No matter which option is selected, in most situations pre-irrigation is generally a good idea. It fills the soil profile to field capacity, germinates weed seedlings that can then be removed by cultivation or contact herbicides, and settles the soil, allowing elimination of high or low areas in the seedbed before planting. With pre-irrigation, sufficient time must be allocated before planting for soil to be dry enough to support planting equipment. A concern, especially during fall and on clay soils, is that rainfall following pre-irrigation may prevent planting for an extended period. For these reasons, some growers choose not to pre-irrigate. The advantage to planting before anticipated rain is that it saves the cost of labor and water for irrigation. However, weather forecasts can be unreliable and, during the optimum planting period in the fall, moisture is not available from precipitation. The advantage to planting and irrigating immediately afterward is the ability to plant during the optimum planting period even though rain is unlikely. To be successful, it is important that seeding depth be no more than 0.5 inch (1.3 cm), and ideally 0.25 inch (0.6 cm) or less. If soil crusting occurs before seedling emergence, additional light irrigations are necessary to soften the surface.

The third alternative, pre-irrigating and planting to moisture, is not without challenges, especially if soil moisture is more than 0.5 inch (1.3 cm) from the surface at the time of planting. Moisture levels can be inconsistent, and too-shallow placement of seed results in uneven stands because some seed germinates immediately and other seed will need additional water before germination. Seed planted too deeply may result in weak seedlings that struggle to reach the soil surface from greater depths. Additionally, wheel tracks from planting equipment are often more frequent following pre-irrigation because, in the effort to conserve soil moisture, planting takes place as soon as possible following irrigation.

FIGURE 4.6

Irrigation must be sufficient to prevent desiccation and crusting, and allow emergence of seedlings, but not allow standing water which encourages diseases.

Early Fall Planting and Irrigation

Many growers irrigate their alfalfa to establish stands during the optimum time in the fall (Fig. 4.6). This is due to the clear advantage of early fall planting versus winter planting. Soil in the root zone must remain moist while alfalfa seed is germinating and the young seedlings are developing. Newly emerged seedlings are not as resilient as established plants, so they must not be subjected to stress from either too much or too little water. Relying on winter or spring rains to germinate seed and maintain young seedlings often results in uneven stands. Even if rainfall leads to successful germination and emergence, subsequent irrigations may be required to maintain seedlings because of a lack of deep moisture in the soil profile and the shallow rooting depth of young seedlings. Roots grow in the presence of moisture, not in search of it, and growth will stop if soil in the root zone becomes too dry. Conversely, over-irrigation may stimulate seedling diseases.

Relying on winter or spring rains to germinate seed and maintain young seedlings often results in uneven stands.

Several methods are used to provide the necessary moisture for germination and seedling growth. Sprinkler irrigation is the best method for providing small quantities of water at frequent intervals to promote germination and seedling establishment. Where sprinklers are not available, growers have successfully established stands using flood or furrow irrigation systems.

Flood Irrigating New Stands

Establishing stands with flood irrigation has been successful on both sandy and heavy soils. It is generally more challenging than using sprinklers, because both uniformity of application and crusting are more difficult to control. If this strategy is to be used, it is extremely important to carefully level the field to avoid high and low spots, since uneven germination will result when high areas don't receive sufficient moisture and seedlings may drown in low areas. This is a more critical issue when flood irrigating seedling fields than when establishing stands with sprinklers. Crusting is a major hazard when flood irrigating during establishment, and growers must have a strategy for additional quick irrigations to prevent crusting, which is not easy to do with flood systems. Another option for heavy soil is to plant alfalfa on beds or corrugations as described previously. In these cases, with good capillary action on heavy soils, water subs across the beds, enabling germination. During the first several irrigations, it is especially important that water drains off within a few hours. Preventing water from backing up into previously irrigated checks will reduce the risk of stand failure resulting from flooding in those areas. Although sprinkler irrigation for stand establishment is the preferred method, growers can flood irrigate new stands successfully by paying careful attention to initial leveling and timing irrigation with weather patterns to prevent crusting.

Sprinkler Irrigating New Stands

Most growers see the advantage of sprinkler irrigation on newly seeded alfalfa from germination through emergence (Fig. 4.7). Growers must weigh the potential yield increase with early planting and the value of current hay prices against the cost of sprinkler rentals, expenses related to labor and management requirements, and the cost of water. Historically, the increased cost for sprinklers has been justified in view of the extra production resulting from early fall planting. If sprinklers are used only during stand establishment, a hand move system or wheel lines are recommended.

Initially, sprinklers should be run long enough to completely fill the top 6 inches (15.2 cm) of the soil profile. Subsequent shorter irrigations may be necessary only to wet the top inch (2.5 cm) or so, to prevent desiccation of the germinating seeds and prevent crusting. Keeping the surface too wet may result in seedling diseases; irrigate just frequently enough to provide moisture for the young, developing seedlings. Run times will vary, depending on residual soil moisture content following the previous crop. Sets that are too long can cause puddling, and seedlings will not survive in those areas. When sprinkler irrigation is used, germination and emergence take only a few days in mid-September to early October, and it is rare not to obtain an excellent stand. Caution is advised to make sure that sprinkler fittings do not leak, leading to washed out or flooded areas. After the crop has reached a more mature stage (e.g., 3–4 trifoliolate leaves) and at least 6 inches (15 cm) of root development, flood irrigation can be used.

The increased cost for sprinklers has been justified in view of the extra production resulting from early fall planting.

FIGURE 4.7

Sprinklers are commonly used for stand establishment. Subsequently, growers often switch to gravity-fed surface irrigation.

Planting to Moisture

Some growers plant to moisture, which can be successful if moisture is very near the soil surface, but it is a riskier approach to stand establishment. Pre-irrigation may provide sufficient moisture for germination. However, alfalfa should only be planted to moisture if (1) sufficient moisture will remain in the root zone throughout the germination process, (2) moisture is present near enough to the soil surface to prevent planting too deep, and (3) good seed–soil contact is assured to allow seeds to take up moisture.

Alternative Practices for Stand Establishment

Companion Crops

Small grains, usually oat, have a long history of being planted as a companion crop during alfalfa establishment. Other forage legumes, like berseem clover, are more recent introductions to companion cropping systems. Companion crops may protect newly emerging alfalfa seedlings from water or wind erosion and have also been shown to suppress weeds and increase first cutting yields. Although establishing alfalfa with companion crops is common in other parts of the country, this practice is not common in California. At issue is stand reduction and lower yields resulting from early competition from the companion crop during establishment. These situations can arise when the alfalfa is planted at a low seeding rate and the companion crop is planted at a higher seeding rate. In general, alfalfa should be planted at the recommended seeding rate (20–25 pounds per acre; 22.4–28.0 kg ha^{-1}), whereas a companion crop of oat should be planted at 8–16 pounds per acre (9.0–17.9 kg ha^{-1}), or berseem clover at 6–8 pounds per acre (6.7–9.0 kg ha^{-1}).

For oat, harvest should take place when oat plants begin to head out, while the alfalfa is still developing below. Raking the field can cause the oat to shatter, creating problems with mixtures later in the season, so raking should be avoided. Short-stature, midseason oat varieties are recommended with early-fall planting because they mature more closely with the alfalfa and are less likely to lodge. In spring plantings, an early-maturing variety will achieve greater growth by the time alfalfa is ready to harvest.

For berseem clover, yield advantages can be expected for the first three to four cuts in the spring. Longer curing times are required for these high-moisture forage mixtures early in the season, so systems where early cuttings are green chopped or ensiled are better suited than hay production systems.

University of California publication 21594, *Overseeding and Companion Cropping in Alfalfa,* contains detailed information on the risks and benefits of companion cropping as well as specific recommendations to improve the chance of success.

No-Till and Reduced-Tillage Seeding

Interest in reduced-tillage systems for alfalfa is increasing; however, research and experience are limited in California. Alfalfa is commonly grown in rotation with silage crops (corn and winter forage) that require heavy equipment at harvest. The greatest concern regarding no-till or reduced-tillage systems is the ability of alfalfa to form a deep taproot without tillage to break up traffic compaction from the previous crop(s). In addition, experience with no-till planting of alfalfa into residues of other crops is limited. Furthermore, alfalfa is typically seeded at drill spacings that are narrower than the 7.5-inch (19-cm) spacing that is common on most no-till drills.

The greatest concern regarding no-till or reduced-tillage systems with alfalfa is the inability to correct long-term soil conditions, including subsurface impediments and surface re-leveling.

There is, however, a growing experience base for establishing crops into older, retiring alfalfa plantings using no-till and strip-till techniques. Growers in Arizona have successfully established no-till, late-planted, double-cropped cotton into alfalfa. Strip-tillage ahead of corn planting has been investigated in several San Joaquin Valley dairy forage production fields with success. Strip-till implements typically include a cutting coulter that cuts residues ahead of a sub-soiling shank that is followed by some type of clod-breaking implement.

The majority of soil compaction research has been done on tillage systems. Soil is compacted to a significantly lesser degree under established no-till systems than under standard tillage systems. Strategies have been identified for the critical and often difficult transition period to no-till. The objective is to maintain yields while allowing the soil to build humus and regain its structural stability so that it will reestablish pore space and be able to resist greater compaction forces over the long term. Over time, soil under no-till management tends to have higher soil organic matter in the surface layer, higher biological activity, including earthworms, and a firm but resilient soil matrix with macropores for air and water movement that better supports traffic than does tilled soil.

Research suggests that soil compaction can still be a significant problem in no-till systems. A number of preventive, as well as remediating, management strategies have been identified to assist in the transition from tillage to no-till and to prevent compaction in no-till systems. Before converting to no-till, an evaluation of the soil profile for yield-limiting compaction should be conducted using an inexpensive soil penetrometer, or by examining root growth. If root growth is restricted or flattened, there may be potential for yield loss if the situation is not corrected. Vertical tillage implements that loosen the compacted soil layer, but that also preserve residues and macropore systems in surface layers, can be used. The first principle for avoiding compaction is to limit traffic to times when the soil is dry. Other considerations for avoiding soil compaction include using dual-wheeled or track-type tractors, taking weights off tractors, and using GPS guidance systems to achieve controlled traffic farming. However, controlled-traffic, conservation-tillage, dairy-forage production systems have not been fully developed or tested in California.

Special Problems During Stand Establishment

Crusting

If a crust forms on the soil surface after irrigation or rainfall, light irrigations may be required to soften the crust and permit seedlings to emerge.

Seed Washing

When flood irrigating a stand to germinate seeds, the force of the water may wash seed from around valve or gated pipe openings. Installing baffles around valves or socks at open gates can minimize this problem.

Seedling Diseases

Seedling diseases are a major consideration during the initial period of stand establishment, especially on heavy soils and under cold conditions. Pre-emergence damping-off by soil-borne fungi such as *Fusarium* sp., *Pythium* sp., and Phytophthora and Rhizoctonia root rots appears to be the most significant seedling disease of alfalfa during stand establishment. There are fungicides available, most often included in seed coatings, that may reduce losses from some seedling diseases; however, they are rarely economical. Most growers plant at high enough seeding rates to compensate for some loss resulting from disease. Planting alfalfa in well-drained soils is the best way to reduce the incidence of these "wet-soil" diseases.

Sclerotinia stem and crown rot, also called white mold, cannot be controlled by fungicides applied to the seed or seedling. This disease can be severe in some areas if the winter is wet or foggy. Although the impact of this disease on seedling stands and future productivity has not been measured, growers in some areas are often reluctant to plant alfalfa before late January–early February because of increased risk of infection.

Insects

Another factor worth considering in newly established stands is the Egyptian alfalfa weevil (*Hypera brunneipennis* [Gyllenhal]). Typically, Egyptian Alfalfa Weevil is not a problem in seedling fields; however, early-planted alfalfa that is established and growing by November can be attractive to adult weevils. Females lay eggs during the winter, creating a larvae problem in the spring, just as with established alfalfa. Monitoring weevil populations in early fall-planted alfalfa fields is especially important. Blue alfalfa aphid (*Acyrthosiphon kondoi* Shinji), pea aphid (*Acyrthosiphon pisum* [Harris]), and cowpea aphid (*Aphis craccivora* Koch) may be a problem in the spring on fall-planted stands. Growers are urged to check fields for the presence of these aphids.

Weeds

Weeds compete with alfalfa for light, nutrients, and water (Fig. 4.8). Depending on the planting date, the environment may be more favorable for weed growth than for alfalfa growth. If weeds are not controlled, they can prevent establishment of the alfalfa and reduce overall productivity and profitability of the stand. Seedling weed control techniques are fully covered in Chapter 8, "Weed Management."

Autotoxicity

Overseeding alfalfa into depleted stands or seeding a new stand into a field where alfalfa has just been removed is usually unsuccessful. When seeding into existing stands, competition may be the major factor that limits seedling establishment, but other factors, such as high levels of pathogenic organisms in the soil and autotoxicity, may also contribute. In fields with a recent history of alfalfa, pathogens and autotoxicity are thought to be most common factors responsible for establishment problems.

Autotoxicity occurs when a plant or plant substance inhibits the growth of other plants of the same species. In research trials, alfalfa extracts significantly increased the number of days to germination, reduced percent germination, and reduced root and shoot length of alfalfa. The toxic substance produced by alfalfa is medicarpin. Autotoxicity is only a factor when alfalfa is being reseeded into an existing stand or in a field where alfalfa has recently been removed.

Overseeding alfalfa into depleted stands or seeding a new stand into a field where alfalfa has just been removed is usually unsuccessful.

FIGURE 4.8

The endpoint of the stand establishment process: a weed-free stand of vigorously-growing alfalfa seedlings. See Chapter 8, "Weed Management in Alfalfa," for a thorough discussion of weed control during establishment.

The degree to which autotoxicity becomes a limiting factor in new stand establishment depends on the age and density of the previous stand. An older stand with high plant density will exhibit greater autotoxicity than either a failed new seeding or an older, sparse stand. Another factor influencing the extent of autotoxicity is the amount of residue incorporated into the soil at the time of stand removal. Medicarpin is water-soluble and is released from the decomposing crop residue. Large amounts of residue result in high concentrations of medicarpin.

A suitable interval must be observed between removal of an existing alfalfa stand and establishment of a new stand, but there is considerable debate as to how long this interval should be. The necessary interval varies with environment, soil, and management. Weather conditions influence the rate at which medicarpin breaks down. Warm, moist soil conditions enhance the breakdown of medicarpin. Some researchers report no autotoxicity problems when a 2–3 week interval exists between plowing or chemically removing the stand and seeding a new stand. In arid climates, the general recommendation is to plant an intervening crop before attempting to establish a new stand of alfalfa where an old one has just been removed. One strategy is to remove the existing stand in the fall, plant a winter forage or cereal crop in the winter, and plant alfalfa again in the spring. An even better strategy is to follow the winter crop with a summer annual, postponing establishment of a new alfalfa stand until September–October, when conditions are optimal.

Frost

Alfalfa seedlings have good frost tolerance at emergence and after the third trifoliolate leaf has developed. There is an intermediate period, during the first and second trifoliolate leaf stages, when alfalfa seedlings are more sensitive to cold temperatures. Therefore, planting early enough to allow time for development to the third trifoliolate leaf stage before the first frost is important. Alfalfa plants will generally survive freezing temperatures if a crown has developed. This allows the plant to store carbohydrates in the roots for winter survival and spring regrowth.

Evaluating Stand Establishment

A seedling stand should not be removed if there is a uniform population of at least 12 plants per square foot (0.09 m^2), although 20 plants per square foot (0.09 m^2) is generally a better initial population. Root size, crown size, and the number of stems per crown should increase annually, compensating for the reduced number of plants, provided the alfalfa is not stressed by short cutting intervals. It is important to reseed thin or bare areas in a newly seeded field as soon as possible to improve the chance of the new seedlings surviving.

Attempting to thicken an established stand by reseeding thin areas is rarely effective. The seeds may germinate, but seedlings seldom survive to contribute to yield in an established stand because of competition, flooding, disease problems, and autotoxicity. It is important to identify the reason the stand was lost before attempting to reseed. If plants died because of disease or flooding, for example, at the end of a check, the condition must be corrected before new seedlings would be able to survive.

Although the point at which established stands should be removed is somewhat dependent on crown size, generally when five or fewer plants per square foot (0.09 m^2) remain, fields become weedy, are less productive, and should be removed. Recent research in Wisconsin suggests that the number of stems per square foot is a better means to evaluate productivity of alfalfa stands than the number of crowns. Results recommended replacing stands with fewer than 40 stems per square foot (measured at 6 inches [15.2 cm] of regrowth) and maintaining stands with 55 stems per square foot (0.09 m^2) or more.

Adequate stand density for optimal production

End of Production Year	# Plants per ft^2 (0.09 m^2)
1	10–20
2	8–12
3	6–9

First Harvest After Planting

Alfalfa plants need to be well established before taking the first harvest. Surplus carbohydrates produced during photosynthesis are stored in the alfalfa taproot, providing energy for regrowth following a cutting. Sufficient root reserves must be available or regrowth may be retarded and yield may be impacted. Growers often rely on the appearance of bloom to determine the appropriate timing for first harvest, but it is important to also evaluate root growth. Roots should be well established before initiating traffic on the stand. If it is questionable whether the stand is ready, err on the side of caution. If early cutting is necessary, allow extra time before the second cutting to ensure that root reserves have been replenished.

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