KEY PRACTICES FOR ALFALFA STAND ESTABLISHMENT

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ABSTRACT

Alfalfa is generally considered a 'weak' seedling that requires special care during early growth before it becomes a vigorous, deep-rooted perennial capable of producing high yields for many years. The principles of stand establishment involve optimizing the conditions for seedling development to the greatest extent possible. The goal of stand establishment should be to "farm for the roots not for the foliage"—that is to produce a deep-rooted, healthy crown during the first 3-6 months of growth. Important elements such as deep tillage, land leveling for flood irrigation, seedbed preparation, variety selection, proper planting date, correct seeding depth, good soil-seed contact, careful irrigation management, weed control, and scheduling first harvests all play an important role in optimizing stand establishment. Paying close attention to recommended practices for stand establishment is critical for long-term highly productive alfalfa crops, and enables alfalfa stands to better compete with weeds and resist pests.

Keywords: Tillage, varieties, IPM, pest management, weeds, soil, agronomic practices

INTRODUCTION

It is difficult to over-emphasize the importance of stand establishment techniques to the long-term productivity of an alfalfa stand. A large component of the success of alfalfa crops occurs during the stand establishment phase. Conversely, mistakes made during stand establishment can haunt the grower for the life of the stand. It is interesting that over 20 years ago, more than half of the 10 most important factors that Vern Marble listed to optimize production occur before or during stand establishment (see "Factors to Optimize Alfalfa Production," Proceedings of the 1990 Alfalfa Symposium, http://alfalfa.ucdavis.edu).

Is it luck or skill? To be honest, a good dose of both luck and skill are needed to have a successful planting. Even when everything is done correctly, failures can still occur. While weather, soils, circumstances, luck and nature can be fickle, there are a range of practices growers can adopt to increase the chances of a vigorous, weed-tolerant, highly productive, high quality, and persistent stand of alfalfa. This article summarizes several important principles for stand establishment

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PRINCIPLES OF PLANT DEVELOPMENT

Knowing how alfalfa seedlings develop is the key to understanding proper stand establishment. Alfalfa is a small-seeded, slow-growing legume, making it somewhat more difficult to establish than many other crops. Due to its small size, the seed contains little energy to support seedling emergence from deep plantings, pushing thorough hard crusts, or to compete with weeds.

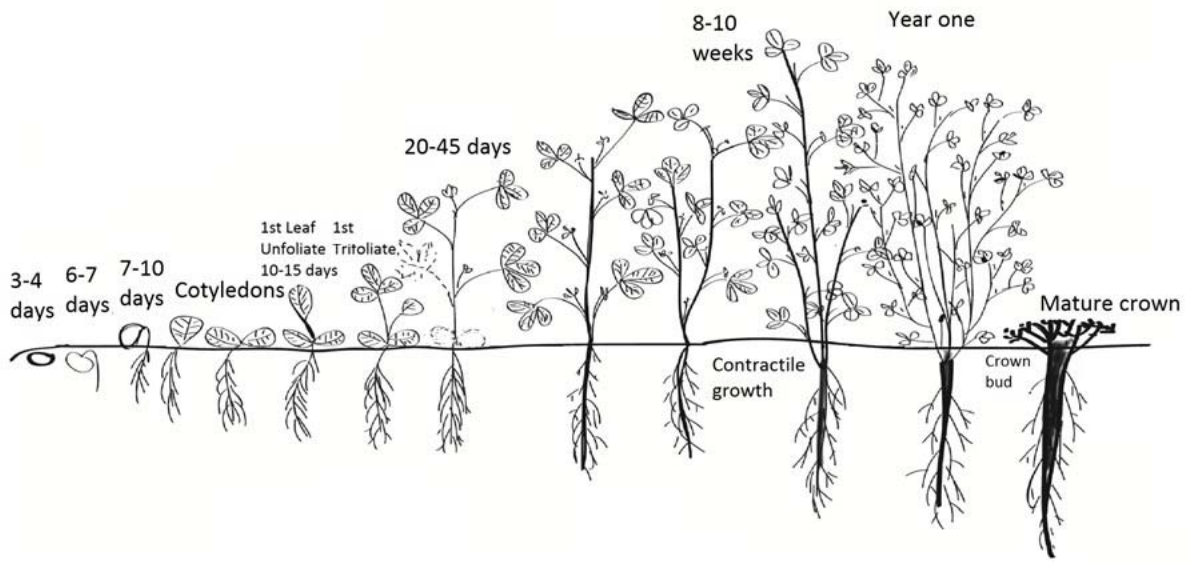

Figure 1. Alfalfa develops slowly from a weak annual to a strong perennial. During contractile growth, the cotyledenary node (2-leaf node) is pulled down into the soil to create the crown, capable of generating new shoots, and the roots must be sufficiently large and deep to store nutrients to sustain frequent harvests. (Mohammad Akmal, illustration)

Temperature and daylength have large influences on alfalfa seedling growth. Optimum temperatures for germination and root growth are 69-76^{o}F while shoot growth optimums are 72-76^{o}F. When temperatures are lower than 42^{o}F, there is essentially no growth. Daylength influences how seedlings use their energy to grow. When days are short (less than 12 hours), more energy goes to root development than to the foliage. Just the opposite is true when daylength is longer than 12 hours.

Unlike annual crops, alfalfa seedlings go through a process of development that includes a transition from a weak annual plant to a strong perennial with a well-developed crown and deep root (Figure 1). During this transition period, which typically lasts several months, the seedling is susceptible to diseases and, in particular, to weed competition. Thus, the goal of the crop manager is to optimize the conditions for quick germination and seedling emergence, rapid

radicle penetration through soil and deep root development, and prevention of the negative impacts of insects, diseases, or weeds.

SITE SELECTION AND ANALYSIS

Alfalfa can be grown on a variety of sites from deserts to fertile valleys and from sandy to clay soils. Different locations may require specific management techniques. It is important to be aware of limitations within a field and to try to minimize their impact. Sandy soils may have excessive drainage requiring different irrigation strategies (e.g. sprinklers). Light soils also more frequently lack certain nutrients. Clay soils, on the other hand, may be poorly drained, requiring specialized drainage or planting on beds. Soils with pH values below 6 should be amended with lime. If high sodium or soil salinity is the problem, reclamation with amendments and drainage may be needed. Most fields that are surface irrigated need at a minimum a "touch up" on the slope to be sure there are no high or low spots. In cases where land cannot be reasonable leveled, sprinklers may be the irrigation method of choice. Subsurface impediments such as traffic compaction or hardpans require tillage to allow for good taproot development (Figure 2).

In addition to physical aspects of the soil, nutritional factors must be considered. Phosphorous and potassium are the nutrients most often needed for alfalfa production, but in some areas of California sulfur, boron or molybdenum may be required. The limitations of a field must be understood, and these limitations will guide practices such as deep tillage, surface tillage practices, installation of tile drains, design and installation of a proper irrigation systems (e.g. flood vs. sprinkler), and development of a soil improvement program, including fertilizers, crop rotation, organic matter, or amendments such as lime and gypsum.

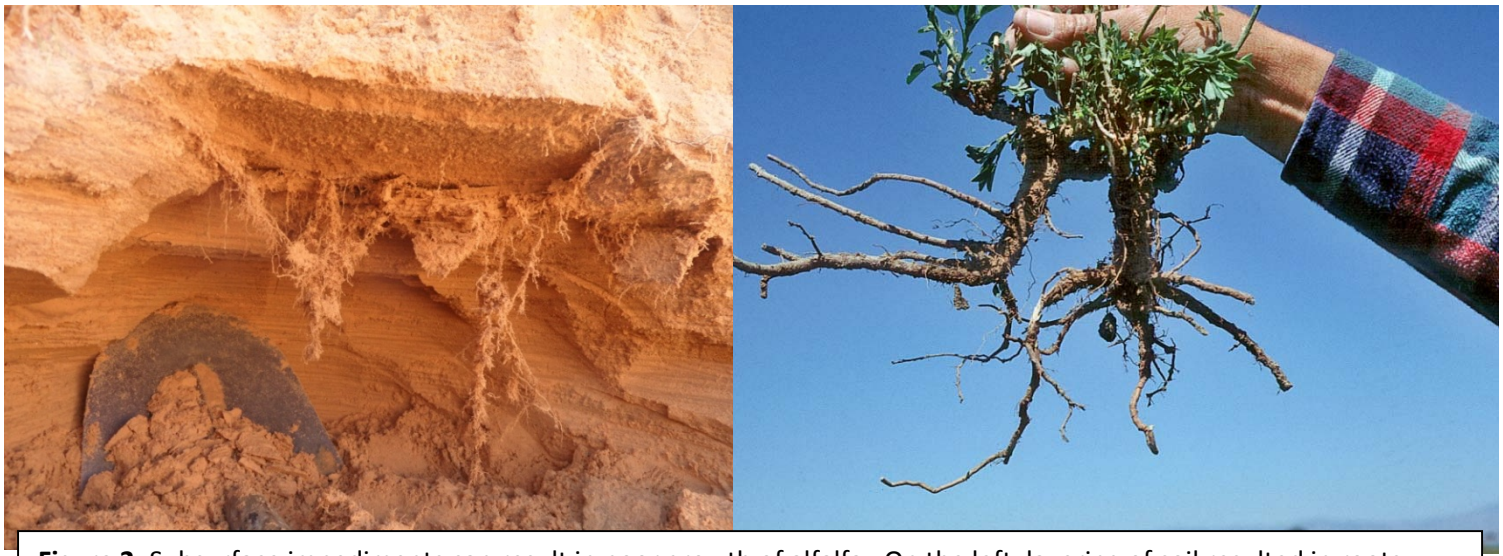

Figure 2. Subsurface impediments can result in poor growth of alfalfa. On the left, layering of soil resulted in roots stopping at 14" depth, in spite of a very sandy soil. The plant on the right encountered a clay layer, with little growth past 10". Deep tillage could address both issues. Detecting soil impediments is an important first step.

TILLAGE, LAND LEVELING AND SOIL PREPARATION

Deep tillage is often recommended for alfalfa to improve rooting depth and water infiltration (Figure 2). A backhoe is a very useful tool to evaluate the need for deep tillage or moderately deep tillage. Under most circumstances a moderate 'ripping' (20 - 30") may be sufficient to break up subsurface impediments and compaction due to wheel traffic. With clay and hardpans, deeper tillage may be beneficial. It is most effective when the soil is dry to maximize the degree of shattering in the compacted zones. Land leveling is critical for surface irrigation systems such as border-strip flood as improper slope for the soil type and volume of water delivery can result in inefficient irrigation. High and low spots can reduce productivity and plant stand. Seed-bed preparation should result in 'firm, but loose' conditions –e.g. a heel print should not penetrate more than ½ inch, and enough loose soil should be on the surface to cover the seed (Figure 3). More stand establishment failures probably occur from too loose a seedbed and the alfalfa seed ending up too deep than to any other single factor. One quarter to 3/8 inch seeding depth is ideal for most soil types; emergence drops off significantly when alfalfa is seeded over an inch deep. Too-fine seedbeds may result in sealing or crusting on some soils.

Figure 3. Allow only ½" heel print before seeding. The soil surface should be firm, but loose enough to cover the seed no deeper than ¼ to 3/8". Seeding too-deep is a common mistake.

CHOOSING THE RIGHT VARIETY AND HIGH QUALITY SEED

The entire genetic capability of the crop is contained in a tiny seed. Thus spending ½ hour studying the yield potential of different varieties from independent field trials (like those at UC Davis, Figure 4) is worthwhile. Do not gravitate to the lowest cost seed – this is a mistake. We estimate an average of 30% yield difference between the highest and lowest yielding varieties over hundreds of location/years of testing in California. At Davis, for example, we often see up to about a 1.5 to 3 ton/acre/year difference due only to variety, a difference that can be worth over $1,000/acre over 3 years (Figure 4). In some cases the seed dealer should PAY the grower to grow an inferior line.

Yield isn't the only thing to consider –disease and pest resistance, fall dormancy, persistence and quality are also important. Growers should take advantage of the many years of breeding done by Universities and private seed companies, who are competing for business by striving to improve yield, quality and pest resistance. Seed quality is also important. Buy certified seed to assure the purity of the variety and the quality of the seed (good germination percentage, free of noxious weeds).

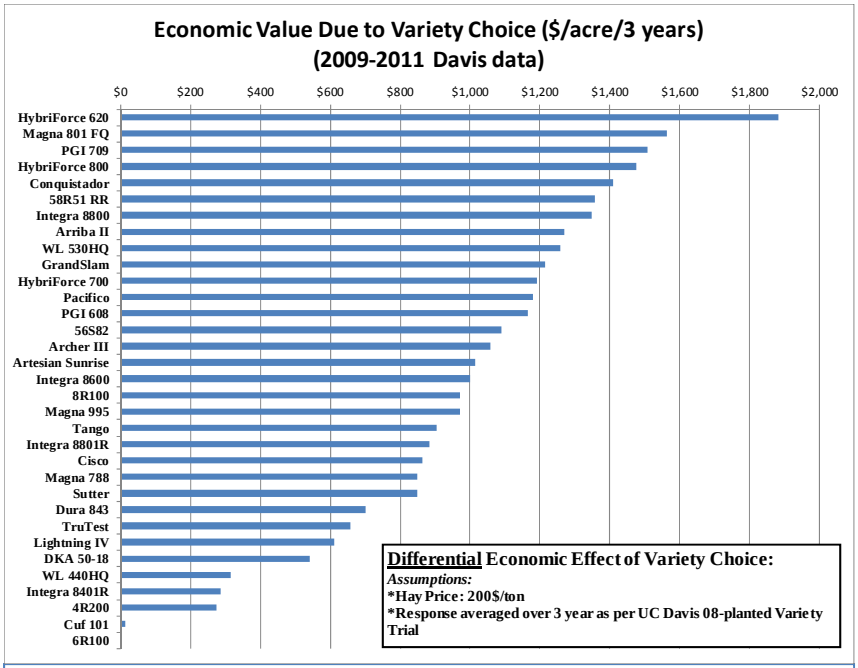

Figure 4. The effect of variety choice alone on 3-year gross returns. The difference due to seed price (e.g. $2/lb or about $75/acre) is minimal compared with variety differences in yield.

University researchers in many states conduct variety trials and results are available on the internet. For California the website is http://alfalfa.ucdavis.edu. The alfalfa seed industry produces a pamphlet with pest and disease resistance ratings for commercial varieties which is available online (http://www.alfalfa.org/).

INOCULATION AND SEED TREATMENTS

Alfalfa is a legume and therefore, with the proper Rhizobia bacteria in the soil, can use nitrogen from the air instead of relying solely on nitrogen in the soil. If there is no recent history (10 years) of alfalfa in a field then seed should be inoculated. Even with a field that had alfalfa relatively recently, applying commercial Rhizobia to seed is a way to assure that the bacteria is present in the field during establishment. It's a good 'insurance policy'. Seed often comes pre-inoculated.

The common seedling damping-off diseases, primarily caused by species of the fungi *Phytophthora* and *Pythium*, are most often a problem when soils are water-logged and the seedlings are growing slowly. Seed treatments with fungicides active against this group of fungi should be helpful if planting during winter months. These diseases can also be avoided by planting when temperatures promote rapid seedling growth, reducing the length of time in which the seedlings are vulnerable.

TIME OF SEEDING: PLANT IN THE EARLY FALL AT MOST LOCATIONS

One of the most important techniques for successful stand establishment is to plant at the right time. It is certainly possible, if field conditions allow, to plant alfalfa almost any month of the year in California's Central Valley and desert regions. However, alfalfa seedlings respond very differently at different times of year.

In short, the ideal time to plant alfalfa is mid-September in the Sacramento Valley, to early October in the San Joaquin and Imperial Valleys. The optimum temperatures for rapid germination and growth (lower 70's) occur in fall and late winter/early spring. During fall, when

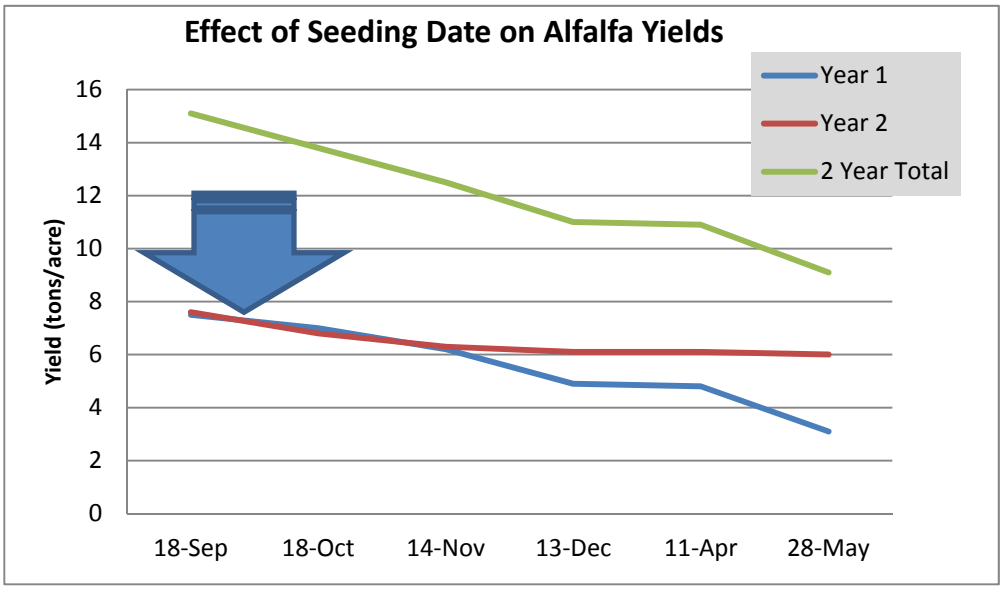

Figure 5. Seeding date can have a large effect on first-year and even second-year yields, as this dataset from Western Fresno County illustrates. Planting in September/October results in higher yields than late fall or spring, and the well-developed seedlings can sustain winter rains, cold, and weed competition.

daylength is short, root growth is favored over shoot growth but in the spring, shoot growth is favored by longer days. With fall planting, not only do short days promote root growth over foliage but it also provides more time for plant development prior to harvest compared to spring planting. Seedlings emerge quickly (3-5 days) in the fall, compared to 10-15 days until emergence in Nov./Dec. plantings (winter plantings). Additionally, early-planted alfalfa produces a vigorous root system and the plant is able to withstand the cold conditions and weed competition that comes in November-January. If crop rotations don't allow early planting, it is often better to wait until early February to plant and avoid trying to establish the crop during the coldest months of December and January when seedlings grow very slowly if at all, winter weeds grow very vigorously, and freezing weather is more likely to occur.

The same principles apply to the Intermountain Region (short-seasoned environment); however, the optimum planting dates differ due to the condensed growing season. The optimum planting window is typically from the second to the last week of August depending on the elevation and the growing area. However, many, if not most, growers choose to spring plant because it is difficult to prepare a field for planting while harvesting other fields and volunteer cereals have been a problem in some late-summer seeded alfalfa fields. Growers should be aware, though, that spring seedings typically yield ½ to 2/3rds that of alfalfa planted in the previous August.

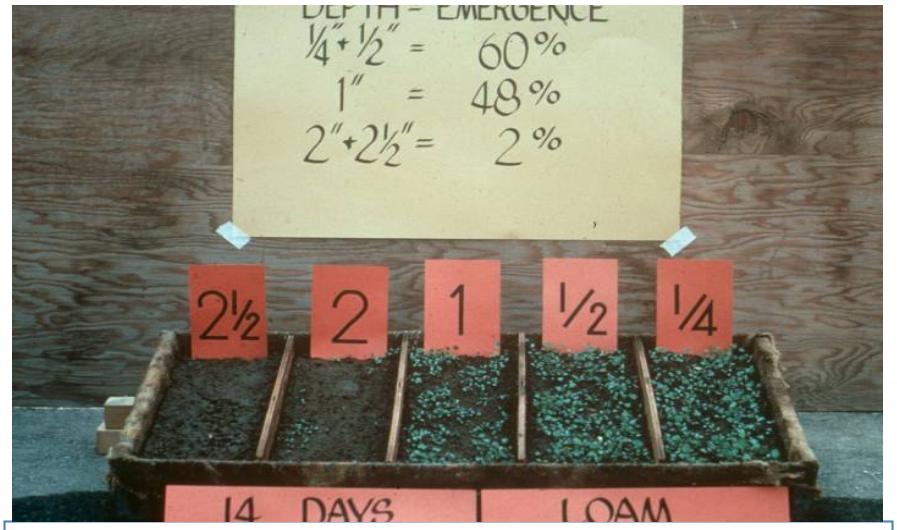

Figure 6. Seeding depth has a large effect on emergence. Seeding depths between ¼" and 3/8" are ideal. 'Fluffy' soils cause seed to be planted too deep. Imprecise methods plant some seeds too deep and some too shallow.

Sclerotinia stem and crown rot is a concern to growers when planting in early fall as this disease can be damaging in foggy, wet winters in some areas of the Central Valley. A recently registered fungicide, Pristine, can reduce the impact of Sclerotinia on seedling stands when applied at first sign of disease. Growers that plant in early fall to take advantage of rapid emergence, good root development and higher yield potential now have a tool to reduce the risk of this disease impacting their stand.

SEEDING TECHNIQUE – DEPTH AND RATE

Alfalfa is usually seeded with drills or by broadcast (air seeders, cultipacker seeders such as a Brillion or by airplane) but the critical factors are accurate depth control and good seed-to-soil contact (achieved by using press wheels or rollers). Alfalfa does not emerge if planted too deep (Figure 6). Poor seed placement (depth) is a very common cause of stand failures. The key point is to assure proper seeding depth (1/4-3/8") – with slightly deeper plantings appropriate for sandy soils,

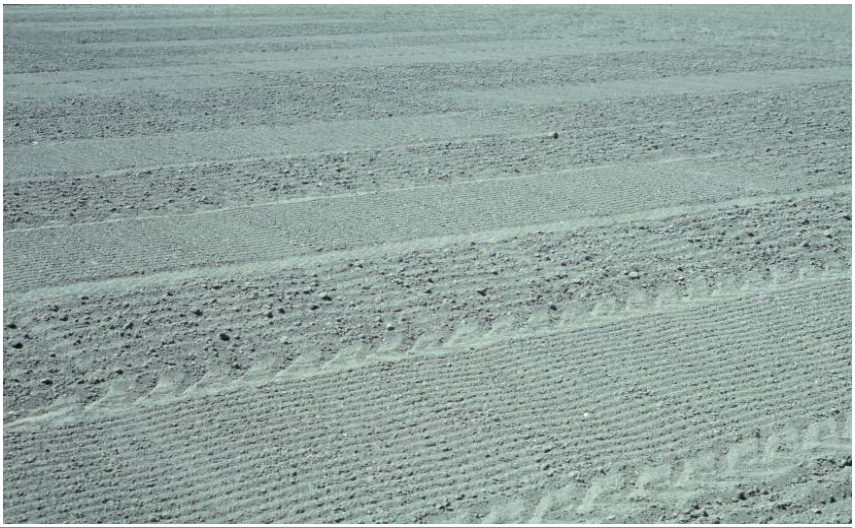

Figure 7. Both drill and broadcast methods can be used, as long as proper seeding depth, soil coverage, and firm soil-seed contact is achieved.

shallower for heavy soils. Many older drills do not have adequate depth control, and must be adjusted, as well as to assure packing wheels are doing their job. Slightly lower seeding rates are recommended for drilled compared to broadcast seeding (Figure 7). Broadcast sometimes provides slightly higher yields the first harvest, but differences generally disappear after that.

Figure 8. Planting alfalfa on top of beds about 24" wide, with 6" deep furrows on heavy soils in Riverside County, CA

Bedded Alfalfa for Heavy Soils. Alfalfa is usually planted on flat, leveled soils but planting on beds has proved to be a highly effective technique for heavy, poorly drained soils (Figure 8). Either 'deep' beds (6-8" furrows, similar to corn, with alfalfa planted on narrow 24" wide beds – Figure 8) or wider beds (up to 60") with shallow furrows (3-4", see Figure 9) can be used. Beds allow water to drain off the field avoiding saturated soil conditions favorable for root disease. Beds are not as effective on sandy soils with rapid drainage.

Table 1. Initial seeding rate effect on stand, survival, and yield (Fresno County data)

Seeding Rate (lbs/acre seed)	1 Month Plants/ft^2	12 Month Plants/ft^2	% Survival	First year Yields (t/a)	Second Year Yields (t/a)
10	12.7	*8.4*	*66*	5.2	6.3
20	21.9	*9.5*	*44*	5.2	6.5
30	30.0	*10.7*	*36*	5.2	6.6
40	35.4	*11.0*	*32*	5.1	6.6
LSD (P=0.05)	3.2	*2.7*		ns	.17

From Mueller et al., 2008, Alfalfa Stand Establishment. IN Irrigated Alfalfa Management for Mediterranean and Desert Zones (http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/)

PLANT DENSITY

Alfalfa is considered a very 'plastic' plant, meaning that a wide range of plant densities will result in the same yield. A 20 lb/acre seeding results in over 100 seeds per square foot, which is plenty, if they all germinate! Generally 20-25 lbs./acre for broadcast and 15-20 lbs./acre for drilled is adequate for a full stand, but research has shown that with careful seedbed preparation and proper seeding depth, lowering seeding rates to 12-15 lbs./acre does not reduce yield and even lower seeding rates have been used successfully in other states. The goal is to achieve 20-50 plants per square foot after emergence. Keep in mind that density will rapidly decline over the first year due in part to competition among the alfalfa plants. Thus even high seeding rates do not result in higher yields compared with a more moderate seeding rate (Table 1). Paying more attention to seedbed preparation and to seeding depth is more important than increasing seeding rates. Reduction in seeding rates is an important cost-savings strategy, especially as the price of improved genetics increases the cost of seed.

PROVIDING APPROPRIATE MOISTURE

Pre-irrigation has several advantages. It germinates weeds that are then killed by the final seed bed preparation. It fills the soil profile so that once a field is planted, only enough water is needed to wet the top few inches of soil so that developing roots can extend into the previously wetted zone. In the case of surface irrigation, the pre-irrigation can alert the grower to any problems with field leveling. Disadvantages include delaying planting and, when planting in late fall or winter, the possibility that heavy rains on top of a pre-irrigation will greatly delay planting. It is highly unlikely that a pre-irrigation in August or early September will be followed by heavy rains, providing yet another reason to plan for the September/early October planting window in the Central Valley. However, this early planting date will most likely require sprinkler or flood irrigation to germinate the seed.

Sprinklers are highly recommended for stand establishment, even if flood irrigation is used later. Although there are labor and water charges associated with irrigating up alfalfa with sprinklers in September/October, the benefit from increased yields the first year usually more than pays for this expense. Sprinklers allow much more control of the water for irrigating up the stand compared to flood irrigation and also provide the added benefit of germinating the seeds on the levees. Additionally, it is risky to irrigate up new plantings using flood irrigation on some soil types, due to washing of seed or rapid crusting. In the Sept/Oct window, seedlings will emerge in 3-5 days. If crusting occurs before emergence, additional water in small amounts should be applied until the seedlings poke through the surface. This is easier to do with sprinkler than with flood irrigation. Regardless of method, growers should be careful not to over-water young seedlings, since the presence of diseases can be made worse with frequent irrigations. Growers should carefully look for the presence of water in the root zone, and if the roots are in moist soil,

you can wait. However, remember that plants grow only when moisture is present next to the root, they can't seek it out 6" below the root!

PROVIDE ADEQUATE WEED MANAGEMENT DURING ESTABLISHMENT

Alfalfa is considered a weak seedling during the first 2-3 months of growth and development, and stands can frequently be overtaken by weeds during this period. Suppression of the growth of young alfalfa seedlings is a common result of excessive weed competition during this period, resulting in reduced vigor and root development and, when severe, loss of stand. In particular with late fall plantings, aggressive winter-annual weeds grow rapidly and can completely shade out young alfalfa seedlings that grow slowly under cold temperatures. Conversely, if the crop

Table 2. Common registered herbicides used in California for alfalfa stand establishment (post-emergence).

Herbicide	Weed Spectrum Controlled	Stage of Growth for application	Rate lbs. a.i./A
Gramoxone Inteon (Paraquat)	Non-selective	3, 6 or 9 trifoliolate leaves	Rate depends upon crop size (0.126, 0.25, 0.25-0.46)
Buctril (Bromoxynil)	Selective-Broadleaves	2-4 trifoliolates	0.25-0.375
Velpar (Hexazinone)	Selective -Broadleaves and some grassy	6-inch root growth/multiple stems	0.25-0.375
Poast (Sethoxydim)	Selective – grasses	2-4 trifoliolates	0.1-0.46
Prism/Select (Clethodim)	Selective-grasses	2-4 trifoliolates	0.095-0.176
Butyrac (2,4 DB)	Selective, broadleaves	1-4 trifoloalates	0.375-0.46
Pursuit (Imazethapyr)	Selective – most broadleaf, some grasses	2-4 trifoliolates	0.047-0.094
Raptor (Imazamox)	Selective – broadleaves & grasses	2-4 trifoliolates	0.03-0.046
Roundup Glyphosate	Non-Selective-must use RR alfalfa varieties	flexible	22-44 oz.

From Canevari, et al., 2007, Weed Management in Alfalfa. IN Irrigated Alfalfa Management for Mediterranean and Desert Zones (http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/)

can be protected during this initial period, and a fully-developed, deep root established, the alfalfa crop is highly resistant to weed intrusion that may come later. It is said that the best protection against weeds is a vigorous alfalfa crop, but first the crop must pass the 'wimp' stage so that it become competitive. Table 2 lists the common herbicides used during stand establishment. Some of these are broader spectrum than others, and some cause greater crop injury than others. Alternatives to herbicides include grazing or mechanical clipping to reduce winter weed pressure to allow alfalfa seedlings to become well established. These strategies are generally 'emergency' techniques where weed control fails or for organic growers. Grazing or clipping works best with early-season planting dates so that alfalfa seedlings are large enough to withstand them. Grazing of seedling stands in the San Joaquin Valley even early planted stands, has not been evaluated. Organic growers have routinely used carefully-managed grazing to manage weeds, since few other options are available. Their experience has been that over-grazing can harm the crop, but grazing is definitely preferred to excessive weed competition. Oat or other companion crops can be used to manage weeds, but care should be taken to reduce the seeding rates (typically below 20 lbs. of oats per acre) so that the companion crop itself doesn't become a 'weed' problem.

NO TILL STAND ESTABLISHMENT OF ALFALFA

No-till establishment of alfalfa is feasible in some situations. However, no-till in alfalfa is more difficult due to the need for removal of compaction layers and soil impediments, proper land leveling for irrigation management, the small, slowly germinating non-competitive seedling, and the need to control weeds. No-till methods have the advantage of significantly lower costs of establishment, particularly energy-consuming tillage operations. No-till (or minimum till) is likely to be more appropriate for sprinkler-irrigated fields where land-leveling is not as critical, and also for soil types where previous compaction is not a serious issue and which lack subsurface impediments. Since alfalfa is so sensitive to subsurface compaction layers, steps should be taken to assure that those are not an issue if this technique is used. Small grains, corn or sudangrass are the most likely rotation crops for stubble seeding, but excess residue is a major problem for alfalfa. Care should be taken to minimize the surface 'trash' since excessive mulch can prevent good soil-seed contact and reduce seedling development. No-till seeding is not common in California, due to the need for deep tillage ('ripping') and land leveling that is required for flood irrigation, which is >85% of the production systems in the Central Valley and desert regions of the state. Greater attention to soil-seed contact utilizing planters that are effective at depth-control and penetration of surface crusts are important for no-till methods. No-till is more approriate for sprinkler-irrigated fields or rain-fed fields following a crop (e.g. wheat) after which the excess straw has been removed.

FIRST HARVEST

When determining when to take the first harvest after establishing an alfalfa field, it is important to think about not only the top growth that's visible but also root and crown development. It is

important to have root development that extends below 12-14 inches, the depth at which wheel traffic tends to compact soil. The crown should be sufficiently developed so that it can withstand the almost monthly impact of harvesting. With a fall planting, harvesting any time after March in the Central Valley should allow sufficient crown development by late March and April, but it is important to examine the crowns and roots to confirm that they are well developed. Check

Figure 9. Sprinkling up seedling alfalfa in Yolo County, CA in the September-October period. This field has been established on 'beds' to facilitate water movement away from the alfalfa plants, preventing diseases during germination, and lack of oxygen ("scald") injury during production.

root development with a shovel. It is better to be patient than to harvest too early and compromise root development for the rest of the life of the stand. Allowing a bit longer than 28 day interval between 1st and 2nd cut will also give the new plants a chance to recover.

SUMMARY

A large majority of success in alfalfa production can be ascribed to what happens during stand establishment. A 'packages of practices' to establish a highly-productive crop of alfalfa is recommended. These include proper site selection, removal of soil limitations with tillage and fertility management, early fall seeding timing, good seeding technique and especially proper seeding depth, effective weed management strategies, proper irrigation, and proper timing of the first harvest. See 'Irrigated Alfalfa Production for Mediterranean and Desert Zones' *http://alfalfa.ucdavis.edu/IrrigatedAlfalfa/* for a more detailed review of stand establishment.