CONSIDERATIONS FOR SUCCESSFUL ALFALFA STAND ESTABLISHMENT IN THE CENTRAL SAN JOAQUIN VALLEY

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INTRODUCTION

Seedling establishment is a critical phase in the life of an alfalfa stand. 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. If a stand fails, replanting requires additional time and expense. Reworking the seedbed can delay planting beyond the optimum time for establishment, and at that point, growers are limited in terms of alternative crops that may take the place of alfalfa. On the other hand, accepting a marginal stand could result in economic penalties, such as lower yields, shorter stand life, weed pressure and reductions in forage quality.

OPTIMUM ENVIRONMENTAL CONDITIONS FOR STAND ESTABLISHMENT

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

Alfalfa seed germinates best at soil temperatures between 65-85°F. If soil temperature is 40°F, it takes alfalfa six days to germinate, but only two days at 65°F. Larry Teuber, at UC Davis, evaluated alfalfa seedling growth and development in response to variations in temperature and daylength and reported the optimum temperature for root growth during the first month was 69-76°F, depending on dormancy class (Teuber, 1988). Shoot growth is optimum at temperatures ranging from 72-76°F. Alfalfa stops growing when the air temperature is below 34°F.

The effect of daylength on alfalfa establishment is less than that of temperature. 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. Days longer than 12 hours favor shoot development while days shorter than 12 hours promote root growth.

Historically, growers in the Central Valley, have planted alfalfa in late fall through early spring to take advantage of winter and spring rainfall for germination and early seedling development. 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

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the chance of successful stand establishment. However, based upon temperature and daylength information, fall planting dates between September 15 and October 31 and spring planting dates between February 1 and March 15 have the greatest potential for successful stand establishment in the San Joaquin Valley.

Several replicated field trials have been conducted to test the recommended planting dates for the Central Valley. In a Sacramento Valley trial, data showed a yield advantage of almost 4 tons the first season for a September planting compared to a March planting (Table 1). 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.

In a second study, the September planting yield advantage over later plantings was even more pronounced than in the previous trial. In the second year after establishment, later planting dates equaled the September planting date in tonnage, but there was still an overall yield advantage of 2.7 and 4.6 tons per acre respectively when the September planting was compared to the November and March planting.

Table 1. First and second year yield data for planting date trials, Yolo County, Sacramento Valley, California, 1977-1978 and 1978-1979 (C. Schoner)

Planting Date	**Yield Tons/Acre (90% Dry Matter)**			**Total Number of Cuttings for Two Years**
1977-1978	**1st Year**	**2nd Year**	**Total**	
14 Sept.	8.1a[†]	9.1a	17.2a	11
17 Oct.	7.3b	8.8a	16.0b	11
16 Nov.	6.2c	8.3b	14.5c	10
21 Mar.	4.4d	8.1b	12.6d	9
LSD (0.05)	*0.57*	*0.43*	*0.88*	
1978-1979				
22 Sept.	8.9a	8.3	17.2	11
24 Oct.	6.1b	9.9	16.0	11
27 Nov.	5.7c	8.8	14.5	10
14 Mar.	4.1c	8.5	12.6	9
LSD (0.05)	*0.42*	*NA*	*NA*	

[†]*Means followed by the same letter are not significantly different at the 5% level of probability. Comparisons are valid only within individual years, not between years. "NA" indicates that statistical information was not provided in the reference source for the table.*

A similar study was conducted at the West Side Research and Extension Center in western Fresno County. There was a 1-ton yield advantage for a September planting date compared to a November planting date the first year, and a 3-ton 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 more than either the December or April planting. It also yielded over 2 tons per acre more for the combined two years than the November planting date (Table 2).

Table 2. First and second year yield data for planting date trial, San Joaquin Valley, West Side Research and Extension Center, Fresno County, 1979-1980.

	Yield, Tons/Acre (90% DM)		
Planting Date	**1st Year 1980**	**2nd Year 1981**	**Total**
18 Sept.	7.4 a	8.3 a	16.5
14 Nov.	6.4 b	7.2 b	14.3
13 Dec.	4.6 c	6.8 b	11.9
11 Apr.	4.5 c	7.0 b	12.0
28 May	3.0 d	6.9 b	10.2
LSD (0.05)	*0.72*	*0.67*	*NA*

Means followed by the same letter are not significantly different at the 5% level of probability. Comparisons are valid only within individual years, not between years. "NA" indicates that statistical information was not provided in the reference source for the table.

In a 1988 trial at the Kearney Research and Extension Center in Fresno County, an October planting produced 0.7 tons per acre more than a November planting and 4 tons per acre more than a February planting. Yields from the fall planting exceeded the increased tonnage that would be expected by simply adding an additional cutting.

Although there are examples of stands successfully established outside of the recommended planting dates, the risk of failure is always greater and other options should be considered. For example, early fall planting dates may be 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. The ground is often too wet to be worked and as planting is delayed, there is a danger that frost will kill the developing seedlings, or winter weeds will outcompete the alfalfa. Under these conditions, spring planting 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 less than optimal conditions.

SEEDBED PREPARATION

In order to plant during the recommended time 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 yields and longer stand life.

Following destruction of the residue 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 to determine the need for preplant or postemergence 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 the vigor of seedling alfalfa 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 preplant or post emergence herbicides provide a longer period of residual control.

Land Leveling
Leveling fields to be planted to alfalfa is extremely important since water must flow evenly over the flat surface. With flood irrigation systems, laser leveling is usually recommended. The field can first be leveled following the deep tillage operation. Then, once the irrigation borders are established, the area between them can be leveled and a uniform slope achieved. The final smoothing of the field is usually done with a land plane to remove any minor irregularities in the soil surface. 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.

Checks and Borders
Levees used with border irrigation serve to guide the water as it moves down the slope through the field. Since an alfalfa planting is kept for several years, great care should be taken in constructing the levees in order to maintain a level surface the full width between adjacent levees. The width between the levees should be based upon the soil type, the slope, the length of the checks, and the flow rate of water available for irrigating the field. Width of harvesting equipment might also 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.

The Seedbed
After the levees are constructed, the checks are generally floated with a drag scraper to prepare a smooth seedbed for planting. The seedbed should be fine enough to allow penetration of the seeder and allow seed covering to ¼-½”, but firm enough to assure seed-soil contact so that the seed absorbs moisture and doesn’t dry out. A grower might use a springtooth to fluff up the seedbed and/or a ringroller or cultipacker to pack it down in preparation for seeding. The final seedbed should be fine, firm, and perfectly leveled with very small clods. Use of press wheels or rolling after seeding may help on many soil types. Excessive tillage to create excessively 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 deep, the seedbed is too fluffy and stand establishment may be negatively affected.

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. If distribution was perfectly uniform and every seed germinated and emerged, a 20 pound per acre seeding rate would result in 100 plants per square foot, far more than is typically observed in a newly seeded stand. Poor seedbed conditions, inadequate seeding depth control, insufficient or excessive moisture, poorer than expected seed germination, seedling diseases, inclement weather, or other factors can quickly reduce the population. Typically, seeding 20-25 pounds per acre broadcast or 15-20 pounds per acre drilled results in 20-50 plants per ft^2 one month after seeding which is considered an adequate stand. In problem fields, higher seeding rates may be justified if the seedbed is rough, the seed is planted late, the seed is broadcast rather than drilled, alkali and salinity are problems, and/or moisture conditions are marginal.

At the end of the first season, generally about 40-50% of the plants remain. Higher seeding rates generally do not result in improved yields or alfalfa stand density except under the poorest of seedbed conditions. A natural thinning process takes place so that, although a stand may look thicker initially, there is no difference in the number of plant per square foot after the first year of production. Lower seeding rates have higher survival rates, resulting in the same final plant population achieved with higher seeding rates (Table 3).

Table 3. Effect of seeding rate on alfalfa plant density and yield the first and second year after seeding. West Side Research and Extension Center, 1979-81.

Seeding Rate (lbs/A)	**1 month after Planting**	**1 year after Planting**	**Percent Survival**	**1980 Yield**	**1981 Yield**
	(Number of plants/ ft^2)			**(Tons dry matter/A)**	
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*

Means followed by the same letter(s) are not significantly different at the 5% level of probability. ns, not significant.

SEED TREATMENT

Seed may be coated or treated for a variety of reasons. One of the simplest reasons is to extend short seed supplies, and 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 1/3 fewer seeds will actually be planted due to the weight of the coating (seed coatings are typically about 33% of the total seed weight).

Coatings are more often used to provide a fungicide or *Rhizobium* bacteria in close proximity to the seed to enhance seedling survival and development. However, benefits of seed coatings (seed treatments) have not been observed consistently in research trials. There is a lot of natural variation in soil populations of pathogens and in their ability to cause disease. Large disease losses will occur in some fields, but not in others. Consequently, there are times when seed treatments will confer a distinct advantage, and times where it does not.

In research trials conducted at the Kearney Research and Extension Center in 1988-89, raw and coated seed treated with or containing a variety of inoculum types and fungicides were compared. Coated seed and raw seed were planted at a rate of 25 pounds per acre. It has been suggested that seed coating will enhance germination so that the same *number* of seedlings will be established despite planting fewer seeds. In general, plant populations were higher when raw seed was planted compared to coated seed. By the end of the first production year, all plant populations were comparable. Coating seed did increase the percent survival of alfalfa seedlings after planting, but planting *uncoated* seed still established a sufficient stand for maximum production. 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 local research and experience, seed coatings do not appear to enhance, but also do not appear to detract from establishing alfalfa stands. The value of seed treatments with Apron or similar fungicides will depend upon the degree of disease pressure. Seed treatments should be viewed as a form of 'risk management' which 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 sub-optimum conditions.

INOCULATING SEED

Nitrogen-fixing *Rhizobium meliloti* bacteria are found in alfalfa root nodules and are capable of fixing almost all of the nitrogen the alfalfa crop needs from the atmosphere. Most fields 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 prior to planting, or a seed company may have applied the *Rhizobium* bacteria to the seed directly or in a coating. When buying inoculant, be sure the word "alfalfa" is listed on the container and check the expiration date. Store the inoculum in a cool, dry place, preferably a refrigerator. If buying pre-inoculated seed, check the date that the seed was inoculated. Seed inoculated more than 6 months prior to planting should be reinoculated. Inoculant should be applied to the seed following the instructions on the package for either the powdered peat or granular types.

SEEDING METHOD

There are essentially two approaches used to plant alfalfa: broadcast methods (including by airplane) and drill planted. 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 all of these methods. Each has advantages and disadvantages.

Broadcast Methods

Several types of seeders are commonly used to broadcast the seed evenly on the soil surface. A cultipacker seeder (brillion seeder) does an excellent job of planting alfalfa since 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. Fluid or suspension seeding techniques are also available. 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. 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 therefore is not recommended.

The seed must be covered to maximize germination and emergence. Most broadcast methods do not precisely control seeding depth, leaving some too deep, some too shallow, so higher seeding rates may be necessary.

Drill Methods

Grain drills, or band seeders, 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. One disadvantage of drilling versus broadcast seedings 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 seedings, 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 or by pulling a cultipacker behind the planter or in a separate operation.

The most important, but often ignored step in the seeding process is calibration of the planter. Manufacturer recommended settings are based on average values, but growers should check actual delivery of seed prior to planting. This can prevent seeding mistakes and save money on seed. 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 vs. raw seed.

SEEDING DEPTH

Recommended seeding depth for most California conditions ranges from ¼ to ½ inch, depending upon soil type and condition. Seed should not be planted at depths greater than ½ to ¾ inch. Only 2% of seeds planted 2.5 inches deep will emerge, but 70% will come through when planted ¼ to ½ inch 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 shallow, or with poor coverage or seed-soil contact can dry our 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 may be too deep if there are no seeds visible on the soil surface. Generally, sandier soils require slightly deeper seeding depth than heavier soils, since they dry out faster on the surface and present fewer soil impediments during emergence.

PROVIDING MOISTURE FOR NEW STANDS

Many growers in irrigated regions irrigate up their new stands, even if they have sufficient rainfall in the winter. This is due to the clear advantage of early fall planting vs. winter planting, and reducing risk of stand failure. Soil in the root zone must remain moist while alfalfa seed is geminating and the young seedlings are developing. Newly emerged seedlings are not as resilient as established plants, so they must not be allowed 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 due to 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.

Flood Irrigating New Stands

Establishing stands by flood irrigating alfalfa after planting has been accomplished on both sandy and heavy soils. It is generally more challenging than using sprinklers, since both uniformity and crusting are more difficult to control. If this strategy is to be used, it is important to level the field to avoid high and low spots. Uneven germination will result when high areas don’t receive sufficient moisture and water may drown out seedlings in low areas. On clay soils that are to be flood irrigated, shorter runs (1/4 mile or less), wider checks (50 feet), and a 1/10 fall will reduce the risk of stand establishment problems. 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 due to flooding those areas.

Sprinkler Irrigating New Stands

Sprinkler irrigation is the best method for providing small quantities of water at frequent intervals to promote germination and seedling establishment. Growers should weigh the value of current hay prices with the cost to rent sprinklers and apply water for timely stand establishment, but historically it has been justified in view of the extra production from early fall planting.

Initially, sprinklers should be run long enough to completely fill the soil profile in the top 6 inches of soil. Subsequent shorter irrigations are necessary only to wet the top inch or so, to prevent desiccation of the germinating seeds and prevent crusting. Keeping the surface too wet may result in seedling diseases. Run times will vary depending on residual soil moisture content following the previous crop. Sets that are too long can lead to standing water, and seedlings will not survive in those areas. Using sprinkler irrigation, germination and emergence take only a few days in mid-September and it is rare not to obtain a perfect stand. Irrigation can shift to flood irrigation after the crop has reached a more mature stage (e.g. 3-4 trifoliolate leaves) and at least 6 inches of root development.

Planting to Moisture

Some growers 'plant to moisture', which can be done if moisture is very near the soil surface as a result of preirrigation or winter rainfall. Preirrigation will settle the soil and allow for the correction of low or high areas in the seedbed before planting. It also fills the soil profile to field capacity, providing adequate moisture for developing seedlings. Another advantage is that preirrigation germinates weed seeds, which can then be removed by cultivation or contact herbicides prior to planting. Preirrigation and planting to moisture is a less expensive method of germinating young seedlings, but it is prone to much higher risk. It should only be done 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 imbibe water.

AUTOTOXICITY

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. The toxic substance produced by alfalfa is called medicarpin. The degree to which autotoxicity becomes a limiting factor in stand establishment depends on the age and density of the stand. An older stand with high plant density will exhibit greater autotoxicity than either a failed new seeding or an older, sparse stand. Medicarpin is water-soluble and is released from the decomposing crop residue. Large amounts of residue result in high concentrations of medicarpin.

Seeding a new stand into a field where the alfalfa has just been removed is usually unsuccessful. In fields with a recent history of alfalfa, pathogens and autotoxicity are thought to be most responsible for establishment problems. A suitable interval must be left 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. It is thought that the interval length varies with environment and management. Warm, moist soil conditions enhance the breakdown of medicarpin. 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

At emergence and once the third trifoliolate leaf has developed, alfalfa seedlings have good frost tolerance. There is a period in between, during the first and second trifoliolate leaf stage 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 ft^2, although 20 plants per ft^2 is generally a better initial population. If the alfalfa is harvested at 1/10 bloom, root size, crown size, and the number of stems per crown will increase annually, compensating for the reduced number of plants. 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.

ADDITIONAL READING

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