

## OPTIMIZING ALFALFA PRODUCTION IN CALIFORNIA

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Alfalfa is grown over a wide range of climatic and soil conditions in the state, from the low desert valleys in southern California where nine and ten cuts per season are common, to the mountain valleys in northern California where two and three cuts are routine. The principal producing areas in the state and their percent of total state acreage are: San Joaquin Valley, 56%; southern California desert valleys, 20% (including 4% from the Mojave Desert); Sacramento Valley, 11%; northern California mountain valleys, 9%; coastal valleys, 4%. These areas represent large variations in harvest management, varietal adaptation, length of growing season, fertility and irrigation requirements, insect and disease problems varying cropping sequences, and different marketing and uses. Putting together one production scheme for such a diverse alfalfa industry is, of course, impossible. Yet, there are important principles that govern the growth of alfalfa that allow us to discuss production practices to a group from such a wide area.

In order to describe practices that would optimize alfalfa production, we have to be able to define those factors that are of greatest influence in limiting yields. In California we have an abundance of problems associated with alfalfa. Several years ago I called together University of California specialists in the areas of agronomy, soils, plant nutrition, irrigation and salinity, plant pathology, entomology, nematology, weed control, agricultural engineering, and economics. I wanted to define factors which could be limiting alfalfa yields in California. We came up with an unbelievably long list - something like 16 major categories, all with repeated subdivisions. Some of the categories were interrelated, some relatively unimportant, and others difficult to rectify. These have been boiled down to those necessary in analyzing steps in optimizing alfalfa production.

### Check List of Factors to Optimize Alfalfa Yields

1. Site Selection
  - A. Soils
    1. Texture
    2. Structure
    3. Profile changes
    4. Water holding capacity
    5. Infiltration rate
    6. Alkalinity or salinity
  - B. Drainage
    1. Surface
    2. Subsurface
    3. Water table
  - C. Water Supply
    1. Quantity
    2. Quality
2. Soil Preparation
  - A. Previous Crop Effects
  - B. Disking or Plowing
    1. Too wet
    2. Too dry
  - C. Subsoiling
    1. Depth
    2. Spacing
  - D. Soil Amendments
    1. Gypsum
    2. Manure
    3. Lime
  - E. Land Planing and Grading
3. Irrigation Layout
  - A. Strip Checks
    1. Width
    2. Length
    3. Slope
  - B. Sprinkler Irrigation
    1. Uniformity of distribution
    2. Precipitation rate
    3. Infiltration rate
    4. Capacity of system
4. Varieties
  - A. Dormancy Requirement
  - B. Stand Life
  - C. Insect Resistance
  - D. Disease Resistance
  - E. Nematode Resistance
  - F. Usage
  - G. Yield Capacity
5. Planting
  - A. Seedbed Preparation
  - B. Seeding Rates
  - C. Soil Moisture
    1. Preirrigation
    2. Germination
    3. Crusting

- D. Time of Planting
- E. Method
  - 1. Broadcast
  - 2. Drill
  - 3. Incorporation
    - a. cultipack
    - b. harrow
    - c. sprinkling
- 6. Fertilization (N,P,K,S,B)
  - A. Diagnostic Analyses
    - 1. Soil
      - a. phosphorus
      - b. potassium
      - c. sulfur
      - d. pH
    - 2. Tissue
      - a. phosphorus
      - b. potassium
      - c. sulfur
      - d. boron
  - B. Preplant Applications
  - C. Applications at Planting
  - D. Maintenance Applications
  - E. Nodulation and Nitrogen
- 7. Weed Control
  - A. Cultural
    - 1. Winter management
    - 2. Cutting schedule
    - 3. Flaming
    - 4. Irrigation timing
  - B. Chemical
    - 1. Seedling stands
      - a. preplant
      - b. post emergence
    - 2. Established stands
      - a. dodder
      - b. summer annuals
        - 1. broad leaves
        - 2. grasses
      - c. winter annuals
        - 1. broad leaves
        - 2. grasses
      - d. perennials
- 8. Insect Control
  - A. Major Insects
    - 1. Alfalfa weevil
    - 2. Pea aphid
    - 3. Alfalfa caterpillar
    - 4. Spotted alfalfa aphid
    - 5. W. yel. striped armyworm
    - 6. Beet armyworm
  - B. Minor Insects
    - 1. Cutworm
    - 2. Leafminer
    - 3. Webworm
    - 4. Clover root curculio
    - 5. Thrips
  - C. Control Measures
    - 1. Chemical
      - a. selection of material
      - b. timing of application
- 2. Biological
  - a. parasites
  - b. predators
  - c. microbials
- 3. Resistant varieties
- 4. Management (cultural)
  - a. strip cutting
  - b. early cutting
  - c. flaming
  - d. oiling
- 9. Nematodes
  - A. Types
    - 1. Root-knot species
    - 2. Stem nematodes
    - 3. Miscellaneous nematodes
  - B. Control
    - 1. Varieties
    - 2. Nematacides
    - 3. Rotations
- 10. Diseases
  - A. Types
    - 1. Phytophthora root rot
    - 2. Bacterial wilt
    - 3. Rhizoctonia root and stem canker
    - 4. Southern anthracnose
    - 5. Scald
    - 6. Root and crown rots
    - 7. Leaf spot diseases
    - 8. Downy mildew
    - 9. Alfalfa dwarf
    - 10. Alfalfa mosaic virus
    - 11. Stagonospora crown and root rot
    - 12. Fusarium wilt
    - 13. Sclerotinia rot
    - 14. Spring black stem
  - B. Control
    - 1. Varieties
    - 2. Cultural changes
    - 3. Rotation
- 11. Irrigation Management
  - A. Water Requirements
  - B. Timing
  - C. Frequency
  - D. Depth of application
  - E. Wetting and Root Depth
  - F. Unit Flows
  - G. Surface Drainage
    - 1. Water logging
    - 2. Aeration problems
    - 3. Disease relationships
    - 4. Weed relationships

## 12. Compaction

- A. Natural
  - 1. Structureless soils
  - 2. Dense subsoils
  - 3. Claypans
- B. Mechanical
  - 1. Plow pans
  - 2. Bulk density
- C. Treatment
  - 1. Deep chiseling
  - 2. Deep plowing
  - 3. Slip plowing
  - 4. Crop rotation
  - 5. Soil amendments
  - 6. Traffic modification

## 13. Harvesting

- A. Cutting Frequencies
  - 1. Varieties
  - 2. Stage of maturity
  - 3. Seasonal differences
- B. Length of Season
  - 1. Fall or winter pasturing
  - 2. Fall cutting
  - 3. Early spring cutting
- C. Soil Moisture
  - 1. Timing irrigations before and after cuttings
- D. Equipment damage to stand
- E. Special Harvesting Requirements
  - 1. Quality
  - 2. Cubes and green chop

Admittedly this is a lengthy list to think about before one can plan and harvest a successful crop. Lack of one or more problems, or failure to recognize a problem shouldn't cause producers to ignore evaluating their practices in terms of this check list. Those who are more successful have been able to develop a system of production which takes into account and applies the most essential of these principles.

A more detailed and specific discussion on each of these important considerations in optimizing alfalfa yields can be found in the Proceedings of the 1971 California Alfalfa Production Symposium, and in the Proceedings for the 1972 California Alfalfa Symposium.

### Select Deep Open Soil

A grower must know his soil characteristics. Production potential is often fixed before a seed is planted by choosing land with problems that cannot be altered or which can only be slowly changed. A good alfalfa soil should be free of salinity or alkali with a pH range of 6 to 7.5. A sandy loam to a clay loam texture is desired, with an internal structure free of lenses, hardpans or dense layers that restrict root development or water movement. Ideally, a minimum of 3 to 4 feet of aerated soil are needed if you are to avoid critical problems with irrigation frequency. A knowledge of the moisture holding capacity--the inches of water that your soil will hold per foot of depth--will guide you in planning an irrigation system and frequency to provide soil moisture at an optimum level. You need good infiltration and internal drainage if you want a stand relatively free of diseases that will last three to four years.

Alfalfa is deep rooted under favorable soil conditions. Significant root development occurs to depths of 6 to 12 feet if not limited by lack of moisture, slow intake rates, restrictive layers, and zones of water saturation.

### Prepare Soil To Eliminate or Reduce Compacted Layers, Hardpans or Abrupt Soil Textural Changes

Alfalfa has a comparatively low tolerance to wet soil conditions during periods of active growth. Diseases such as phytophthora root rot and scald, which is caused by a lack of oxygen in the root zone for a prolonged period, reduce stand life. Internal drainage can be improved, at least for a short period, by deep subsoiling, or deep plowing to breakup compacted layers or to eliminate a plow sole. Frequently overlooked is the presence of textural differences within the soil profile. Layers of sand within a loam or clay loam soil act as soil moisture barriers, frequently holding up moisture movement for prolonged periods. Many soils, including shallow, hardpan or heavy clay soils, can be modified to grow alfalfa if enough care is taken in the preplant land preparation, irrigation system development and irrigation techniques.

High sodium soils should be amended with a calcium source such as gypsum. Tests to determine the approximate quantity of gypsum are available. Organic matter should be added through animal manures or cover crops to help reduce the soil bulk density, aid soil aeration and water penetration, and promote good root development. When used in conjunction with deep tillage, organic matter additions to coarse sandy soils has assisted in improving soil structure and alfalfa growth.

Develop A Well Designed Irrigation System  
For Your Soil Conditions

A well designed irrigation system can often increase yields by 50 to 100%. A poor system cannot be compensated for by altering irrigation practices. Proper irrigation begins with plans for the system before planting. Three objectives should be kept in mind:

- 1) A continuously available soil moisture supply to avoid stress throughout the cutting interval must be maintained.
- 2) A healthy soil environment for root growth and development is necessary. Water-logged soils exclude oxygen needed by the roots, or promote root rotting diseases
- 3) A profitable return from the irrigation system investment through increased efficiency in the use of water, labor, power, and equipment.

Border Irrigation. Most alfalfa is irrigated by the border or strip check method. Standards for border widths, lengths and unit flow of water for various soil types and slopes are published elsewhere (1971 Proceedings, California Alfalfa Production Symposium). A slope of 0.2-0.6% and a side fall no greater than 1/10 of a foot (1.2 inches) between irrigation borders will accomplish the essential requirement of moving water as a uniform sheet between the levees. The most serious irrigation problems occur on fields without sufficient slope to provide surface drainage to remove excess water. Water which does not infiltrate into the soil within a few hours should be removed from the field by means of a drainage ditch installed across the lower end of the field. Some growers have successfully grown alfalfa on very dense, heavy clay soils by using irrigations 2 to 4 inches deep and 24 to 80 inches apart.

Fields should be land planed to eliminate pot holes or high spots. Newly leveled fields sometimes settle where deep fills were made during land grading. These spots must be eliminated before replanting to alfalfa. Better yet, plant newly leveled fields to barley or some other crop and touch up the field before planting to alfalfa.

A knowledge of the quantity of water your system will provide is necessary in order to adequately plan the size of your checks. Growers should become familiar with the words "unit flow per foot width of strip check". The unit flow is the amount of water suggested to be turned into each check per foot of check width. For example, alfalfa planted on a sandy loam soil with a slope of 0.2% with checks 40 feet wide would require a unit flow of about 30 gpm per foot of width, or 1200 gpm turned into each check. One is then in a position to know whether or not his system will deliver the quantity of water needed during peak requirements. In this regard, producers need to know: (1) how much moisture is required during the peak water use months of June, July and August; (2) what his irrigation efficiency is; (3) how much available moisture his soil will hold per foot of soil depth and (4) if his soil will infiltrate that quantity of water in the proposed time period. This kind of information together with information on the proper check widths and lengths will enable an operator to calculate whether or not he can satisfy the water requirement for optimum production. For example, given an efficiency of 75%, and a water requirement of about 9 inches per month during the mid-summer, an operator can calculate that he must apply about 12 inches of water per month in order to keep his alfalfa growing vigorously. With this information he is in a position to determine how many irrigations per cutting he must make if he is to successfully grow alfalfa under his particular set of soil conditions.

Sprinkler Irrigation. Many alfalfa fields are now irrigated by means of sprinkler systems of varying designs. Basic criteria of a good system includes:

- 1) Uniform water distribution to all parts of the field
- 2) A precipitation rate less than the infiltration rate of water into the soil.
- 3) An ability to deliver the depths of water at the frequencies needed to satisfy the peak water requirements (mid-summer) of the alfalfa.
- 4) An investment that is economically sound.

Sprinkler systems designed with the above in mind should perform more efficiently than flood irrigation. Some systems have been so poorly designed that a grower cannot cover his entire ground during periods of peak water requirement. This is a most critical point since moisture stress will directly affect yields. Highest efficiency of sprinkler equipment can be obtained only if the system is designed for nearly continuous operation during this peak water use period.

A thorough knowledge of soil characteristics is as essential to optimizing production under sprinklers as it is under flood irrigation. Infiltration rates, soil-moisture storage capacity (determine by multiplying the water holding capacity per foot of soil depth by the depth of the soil root zone), must be known if proper precipitation rates and sprinkler spacings are to be made. A more detailed evaluation of sprinkler systems is contained in the 1971 Proceedings of the California Alfalfa Production Symposium.

#### Provide Adequate Quantity and Distribution of Soil Moisture

Irrigation frequency and quantity of water applied are recognized as the most important cultural practices made by individual growers. The only practices which can be changed after the alfalfa has been established are the: (1) frequency of irrigation; (2) the size of the stream turned into each border check, and; (3) the time the water flows into each check. There is no one system that can be described since alfalfa is grown under all kinds of conditions where difficult water holding capacity, rooting depth, infiltration rate, water table, etc. are encountered. Producers should have the following information available in order to make proper decisions on irrigation timing and amounts.

1. Know your water requirements. Water requirements vary from one area in California to another, with total yearly consumptive use in Imperial Valley, the San Joaquin Valley, and the Sacramento Valley being respectively 79, 59 and 53 inches. Monthly consumptive use data are available from the office of U.C. farm advisors. Peak use in mid-summer will vary from .1 inch per day in the coastal areas, to .25 inches a day in coastal valleys, to .3 inch per day in the central valleys, to .35 inches per day in the desert areas.

2. Determine water holding capacity. Water available for plant use per foot of depth varies according to soil texture as follows: sands, 1/2 inch - 3/4 inch; sandy loams, 3/4 inch - 1 to 1 1/2 inches; clay loams, 1 1/2 inch to 2 inches; clays, 2 inches - 2 1/2 inches.

3. Determine depth of soil available for rooting. The soil-water storage capacity of your soil can be estimated by multiplying the water holding capacity per foot of depth of soil by the depth your root zone. Producers should be aware of textural differences within the soil profile in order to accurately estimate this soil-water storage capacity. Rooting depths can be estimated by backhoeing an observation pit or by sampling soil at various depths.

4. Determine the water intake rate for your different alfalfa soils. A soil probe (a 4 foot by 1/4 inch iron rod with a T handle) can determine the depth of water penetration after an irrigation since it stops when it meets dry dirt. Most soils in California have intake rates less than 1/3 inch per hour, and some more dense soils less than 1/10 per hour. Most poor producing alfalfa fields are due to inadequate soil moisture available over a continuous period of time to promote optimum growth. Some operators have improved water penetration without serious stand loss by surface tilling in the fall with 1/2 inch fertilizer shanks spaced 18 inches apart and running at a depth of 5 to 7 inches. Low infiltration rates on shallow, dense or hardpan soils can seriously limit yields. By decreasing the quantity of water (unit flow) released in each check, decreasing the length of run, increasing the application time, and/or increasing the frequency of irrigation within the limits of cutting frequency requirements, more water can be made available to the root zone over a longer period of time, thereby improving alfalfa production.

Pre-irrigation. Nearly all alfalfa fields should be preirrigated to a depth of anticipated root development. This deep reservoir will then be available during summer months when irrigation frequencies may not keep up with water use. Keep in mind that 70% of alfalfa's water needs come from the top half of rooting depth. In most areas of California, winter rains only partially refill the exhausted soil water reservoir. Winter irrigation will be beneficial and eliminate poor growth areas appearing in late August and September. A soil probe will tell you the depth of wetting of your winter moisture, as well as after each irrigation, and allow you to add enough water to refill the soil.

Irrigation frequency. This will depend on the capacity of your soil to hold moisture. Very few soils in California can support alfalfa growth over a 28 to 33 day cutting interval in the summer with only one irrigation. Many producers are reluctant to use two irrigations in an attempt to have the soil surface dry when the hay is swathed. Most soils will not accept in one irrigation the 9 to 12 inches required to maintain growth for one month. Those who have adopted a two irrigation schedule have improved yields. Shallow or sandy soils may require exact control of water applied in three and four irrigations per cutting. Super saturated conditions must be avoided since phytophthora root rot can only develop with free water present within the soil profile for several days.

One of the greatest limiting factors in alfalfa production is the extended time from the last irrigation before cutting until water can be applied after removing the bales. Many operators, especially those using field cubers, want the soil dry up to 10 days before windrowing. This 10 day period is extended to 15 and 17 days before water can again be applied after removing the alfalfa from the field. Most alfalfa will stress during this time and regrowth will be slowed or entirely stopped. I have seen many fields that have no regrowth at all after cutting until the first irrigation. Four or five days of drought following several cuttings can eliminate one entire cutting per year. When water is available, new buds must be regenerated at the crown, which can delay recovery up to 10 days. Fields that have restricted root development or which have a low water storage capacity will have to be irrigated closer to cutting than deeper soils. The danger of compacting moist soils and problems in curling hay windrowed on damp soil may be less than the yield reduction suffered by allowing severe drought to occur during curing.

Alfalfa should not be irrigated after cutting until a canopy of leaves completely shade the ground. Fields irrigated without this canopy can expect an accelerated infestation of summer grassy weeds such as watergrass or pigeongrass which require light in addition to moisture to germinate.

Over irrigation also can reduce production. Phytophthora root rot is associated with heavy soils, hardpan, plow pan and lensed soils that have poor internal drainage that cause water to accumulate within the soil profile. Scald, a misnamed physiological disease caused by lack of oxygen in water saturated root zones, and rhizoctonia root canker, cause stand loss when water is held on fields during hot weather for periods in excess of 8 hours. Flooded-out ends of checks limit yield and act as weed seed reservoirs. Many of these spots could be eliminated by establishing a surface drain to remove excess water.

#### Select a Variety With Best Characteristics For Your Soil

Important alfalfa variety factors will vary from area to area and according to individual grower's use, but should include: correct winter dormancy for area, moderate to long stand life, an adequate yield, the ability to produce adequate quality, and resistance to the major diseases and insect pests.

Winter dormancy. Alfalfa varieties grown in California may be divided into three rather broad groups: (1) those which are non-winter dormant, capable of slow growth during the winter months in central and southern California; (2) those intermediate in winter dormancy, which normally produce very little winter growth when cut after mid-October; (3) those which are very winter dormant and which can withstand cold temperatures experienced in the high elevation mountain areas of northern California. This broad classification is increasingly difficult to maintain since there are variations in winter dormancy within all three groups. I prefer to classify alfalfas grown in California into four groups with the addition of a "very non-dormant group" which has more growth in the winter months in the southern San Joaquin Valley and the low desert valleys of southern California permitting grazing, green chopping and dehydration. A listing of all known public and private alfalfa varieties and brands sold in California (except only public varieties in the winter dormant class) follows:

Alfalfa varieties and brands grown in California.

Very Non-Dormant	Non-Dormant	Semi-Dormant	Dormant
Abunda Verde Brand	AS-13*	AS-49	Grimm
Bonanza	DeKalb Brand 183	Caliverde 65	Ladak
Callente	El Camino Brand	Cody	Narragansett
Converde 94 Brand	8-19 Brand Alfalfa	Condura 72 Brand	Rambler
El Unico	El Camino Brand WL 450*	DeKalb Brand 167	Ranger
Hayden	El Camino Brand WL 451*	Eureka Brand	Rhizoma
Mesa Sirsa	El Camino Brand WL 508	Kanza	Vernal
Niagara N-71 Brand	Germain's Eldorado*	Lahontan	
Sonora	Germain's Eldorado R	Messilla**	And many other
Sonora 70	Joaquin 11	Niagara N-78 Brand**	public and private
U.C. Salton	Moapa	10-19 Brand	varieties
Imperial 70 Brand	Moapa 69	Resistador**	
	919 Brand*	Washoe	
	U.C. SW-44		

\* Known to be only slightly more winter dormant than Moapa.

\*\* Known to be less dormant than Lahontan, and will produce more fall growth than Lahontan.

In comparison to non-winter dormant varieties such as Moapa, semi-dormant varieties do not begin growth as early in the spring, are slower recovering after cutting and require 2 to 4 days longer intervals between harvests to reach 1/10 bloom, and stop growth earlier in the fall. Variety trials conducted in the Sacramento, San Joaquin and Imperial Valleys over the past 15 years indicate a yield reduction for semi-dormant varieties of 5-15%, 10-20% and 20-30% for the above areas respectively for three year stands planted on well drained soils and cut on a 28-33 day cutting interval.

Stand life. Since most semi-dormant varieties, for example Lahontan, will maintain a productive stand longer than most non-dormant varieties, higher yields are often obtained during the fourth, fifth and subsequent years from the semi-dormant varieties. This fourth and fifth year advantage is usually not enough to overcome the greater yielding ability of the non-dormant types for the first three years. Recently, there have been several non-dormant alfalfa varieties released with greater resistance to phytophthora root rot and other stand reducing diseases and insects which hopefully will result in more productive stands into the third, fourth and fifth year. A few of these may be good enough to replace Lahontan on very heavy, wet soils where Lahontan has proven its ability to persist. There is no doubt that more hay is produced by these newer types than by Lahontan.

The economic advantage of increased stand life is obvious when cost studies indicate \$70 to \$90 to establish an alfalfa stand. Yearly amortization costs for a three year stand are approximately \$27, while on a four year basis it is only \$20. Your individual advantage is obvious, but when considered over the state, adding one more year to our average three year stand life, would return a little over \$8 million to California alfalfa growers. Obviously, it would not be economical to plant a semi-dormant variety, such as Lahontan, except in areas with severe phytophthora and stand loss problems beginning at the end of the first or second year, since the yield advantage of the more non-dormant varieties will more than offset the \$7 per year amortization cost.

Stand life is a function of many factors other than dormancy, but usually non-dormant (especially the very non-dormant) varieties are shorter lived than semi-dormant varieties. As mentioned previously, root rotting diseases such as phytophthora root rot, rhizoctonia root rot, scald, bacterial wilt, alfalfa dwarf and the crown rot complex are the major contributors to stand decline. However, we shouldn't overlook the effect of root knot nematodes in our sandy soil areas, stem nematode in coastal areas and Antelope Valley,

southern anthracnose which is turning up in stand decline problem fields all over central and southern California, and other more minor crown and root rotting organisms. Cultural practices also influence stand life. Continuous fall or winter grazing by sheep, cutting intervals less than 28 days which harvest alfalfa in the bud stage and seriously reduce vigor, the damage from repeated field traffic to alfalfa buds and crowns that promote diseases and early death of plants, compaction, irrigation frequency, drainage characteristics, alkali, and winter kill in cold areas, all affect how long a stand will remain productive.

Variety selection boils down to a knowledge of variety characteristics, some of which are more important than yield, combined with a thorough knowledge of your own soils and cultural practices you intend to impose on the variety. Varieties do differ in their plant characteristics, resistance to insects, diseases and nematodes, and in their yielding ability. While the choice of a variety is important, and it can be vital for economic production on problem soils, attention to the important production practices outlined in this discussion will be a greater influence on total production than will the choice of a variety. Until growers are producing at a much higher level than our average 5.8 tons per acre in 1972 indicate, production practices need more attention in order to obtain the 10-12 tons optimum yields from the varieties now being used.

#### Don't Short-Cut When Establishing Stands

Seeding rate trials have been conducted in California which substantiate a 20 to 25 pound seeding rate as adequate under all but very poor seedbed conditions. If every seed germinated, 10 lbs/a would establish 50 plants per square foot. Many successful seedings have been made with drill and airplane plantings at 15 lbs/a under adequate germination conditions. A firm, moist seedbed, a planting depth of 1/4 inch to 3/4 inch, ring rolling or cultipacking following a broadcast seeding and a soil temperature above 40°F all are necessary to insure a good stand. When the seedbed is rough, the seed broadcast rather than drilled, some alkali and salinity exist, and moisture conditions marginal, seeding rates of up to 30 and 40 pounds are probably justified.

What constitutes an adequate seeding stand? Seeding 20-25 lbs/a under average conditions will establish 30 to 60 plants per square foot one month after seeding. At the end of the first season, about 40-50% of the plants will remain. Lower rates have up to an 80% survival and higher rates a much lower, with about 30% of the plants left after 6 months. You have an adequate stand for optimum production if 12 to 18 plants remain at the end of the first production year, 10 to 15 at the end of the second, 8 to 12 at the end of the third, and 6 to 9 at the end of the fourth and subsequent years. If a 1/10 bloom cutting schedule is practiced, root, crown size, and stems per crown will increase yearly, compensating for the reduction in plants. In central and southern California, the point at which stands should be removed is somewhat dependent on crown size, but when 5 or less plants per square foot remain, fields become weedy, less productive, and are in a general state of decline and should be removed. In mountain areas where winter dormant varieties are grown which have much broader crowns, a lower plant count (3-5) can be tolerated before stands should be removed.

Fall versus spring planting. Fall planting before November 15th is preferred over late winter planting, January through March, if the previous crop has been removed early enough to allow for adequate seedbed and irrigation system preparation. Advantages include:

- 1) A 20-30% yield increase in first year.
- 2) Rapid germination and establishment due to warmer temperatures.
- 3) Reduced likelihood of soil compaction from working wet soils
- 4) Increased vigor and ability to compete with weeds.

Spring plantings are recommended only when a severe winter weed problem exists and chemicals cannot be used for their control. Plantings after March 15th becomes more hazardous every day. Late fall removal of the previous crop should not be used as an excuse for spring planting since fields are invariably worked when they are wet and the necessary preplanting operations cannot usually be done without damaging soil structure. A fall planted winter cereal, an early maturing summer annual crop, and a delay in alfalfa planting

by one year may be a better alternative to spring seeding under conditions described above

In mountain areas, optimum first year yields can be obtained by an August seeding. Where crop rotation prevents this, seeding pure alfalfa as early in the spring as seedbed preparation will allow will produce from 3 to 4 1/2 tons of high quality hay per acre.

Seeding with a companion crop is not recommended except where wind and sand may blow out unprotected alfalfa seedlings.

#### Determine Fertilization Requirements

High yields of alfalfa remove large amounts of nitrogen, potassium, calcium, magnesium, phosphorus and sulfur. The nutrients most commonly in low supply in California are: phosphorus, sulfur, potassium and boron. Nitrogen is rarely required, and never needed if soil conditions are satisfactory for the growth of bacteria supplying atmospheric nitrogen to the roots of alfalfa. Calcium is rarely deficient, but the addition of ground limestone may be necessary to make alfalfa grow well on some acidic soils and to raise the soil pH to 6 or above so that nitrogen fixing bacteria will flourish. Occasionally, especially in cases of restricted root development or uncorrected soil pH of less than 5.5, nitrogen fertilization may be temporarily justified. Except on peat or muck soil, pH values of 5.0 and lower are associated with poor alfalfa growth, little or no nodulation, and stubby roots due to toxic amounts of aluminum. These soils must be limed in order to grow alfalfa. Peat or muck soil with pHs between 5.0 and 6.0 often grow good alfalfa since nitrogen is available from the decomposition of the organic matter. Soil variability in California and past cropping and fertilization practices make blanket fertilizer recommendations impossible.

Soil analysis. A soil analysis prior to planting is helpful in determining what, not how much, fertilizer to use. Because of the great depth of the alfalfa root system it is difficult to be certain that responses will occur even when a deficiency is indicated by soil analysis. Phosphorus, potassium, sulfur and possibly zinc in rare instances, are all possible to diagnose with soil analysis. If soil values for P ( $\text{HCO}_3\text{-P}$ ) are over 20 ppm, exchangeable K over 100 ppm and  $\text{SO}_4\text{-S}$  over 20 ppm it is very unlikely that a response from P, K or S fertilizers will be obtained. Values below 10 ppm, 50 ppm and 10 ppm for P, K and  $\text{SO}_4\text{-S}$  respectively, are likely to respond.

Plant analysis. Plant analysis only reflects with certainty the nutrient that actually limits growth. If P is low, for example, values for S and K will not reflect potential supply of those nutrients. Plant analysis will help us pick out the limiting factor. After correction, you must then reexamine the revised status of other nutrients and deficiencies. Only rarely will more than one nutrient deficiency occur together. Standards have been developed for phosphorus, potassium, sulfur, boron and molybdenum. (See 1971 Proceedings, California Alfalfa Production Symposium.) Samples should be taken from plants in the 1/10 bloom stage or the published standards will not hold.

Deficiency symptoms. Plant symptoms can be useful in identifying fields needing fertilization. (See AXT-376, "Alfalfa Analyst".) Deficiency symptoms of potassium, sulfur, boron and iron are fairly easy to distinguish. Phosphorus has no real specific symptoms other than small, narrow leaves and weak growth and a dark bluish-green cast. Deficiency symptoms usually indicate a problem that should have been corrected long ago.

Field strips. Field size experiments are usually necessary to determine the most economical amounts of fertilizer to be used. Plant symptoms, plant analysis, and soil analysis tell us what nutrients we need to add as fertilizers but as yet no substitute has been found for well layed out tests and demonstrations to show how much fertilizer may be profitably used.

#### Select Proper Harvesting Schedule

Harvest frequency is related to the regrowth characteristics of alfalfa varieties and how the different climates in California affect the rate of alfalfa development. It affects yield, quality, vigor, and stand life. For a complete discussion of these interrelationships, see the 1971 Proceedings, California Alfalfa Production Symposium.

What harvesting program will return the most production of hay per acre? Usually we must compromise between maximum production and quality. Alfalfa should be cut when it reaches 1/10 bloom rather than on a fixed cutting interval schedule. Stage of maturity is a more accurate measure of alfalfa development since it reflects reduced growth and development during cool periods, and accelerated development during hot weather and when the alfalfa is under moisture stress. Cutting alfalfa in the 1/10 bloom will give nearly maximum hay yields, acceptable quality for marketing, and the highest total production of digestible nutrients per acre for those who use their own hay. Summer harvests are lower quality. Spring quality is possible by cutting earlier in the late bud stage. Cutting in the bud stage will reduce total production by about 15%, increase weediness by 200%, increase harvest costs by 1/3 because of one or two more cuttings per season, but will be of higher quality than hay cut in the 1/10 bloom stage. By delaying cutting to the 1/2 bloom stage, production is increased by 1 to 5%, but the quality is reduced, especially in mid-summer. Alfalfa produced under slight moisture stress on heavy and often salty soil conditions, that is short and fine stemmed, can be cut in the 1/2 bloom without seriously affecting quality.

Increasing the cuttings per season does not increase total seasonal yield if the alfalfa is cut at 1/10 bloom stage or earlier, but will increase harvest costs and yields will be lower. Non-winter dormant varieties such as Moapa, do not increase in yield after the early bloom stage is reached.

Late fall and early spring harvesting. Total yield can be increased by delaying the date of the first cut by one or two weeks. Delaying the first cutting in Fresno County from March 25 to April 3 -- a nine day delay -- increased yield of the first cutting by about .6 ton per acre. The same cutting interval was then imposed, but the benefit from the original nine day delay was expressed in a second cutting yield increase of approximately .5 ton per acre.

Earlier cutting, such as with dehydration operations, or by sheeping in the early spring would reduce yields even more. Many producers wish to use fall growth for sheep feed or for dehydration purposes. Repeated defoliation over a long period of time in the fall depletes root reserves and reduces plant vigor. I have seen many weed-free fields sheeped off in the fall become weed patches the following spring because the weeds have more vigor than the alfalfa.

Varieties differ in their ability to withstand frequent cutting. Semi-dormant varieties such as Lahontan and Caliverde 65, suffer a greater yield loss, a decreased stand life, a greater invasion of weeds because of reduced vigor when repeatedly cut in the bud and prebud stage, and have a slower recovery after cutting than non-dormant varieties such as Moapa. In extremely hot weather, over 100°F with warm nights, non-dormant varieties cut in the bud and early bloom will die rapidly and must be cut at least in the 1/4 bloom to maintain stands past the first year. This interaction between varieties and cutting frequency mean that growers with several different varieties must be aware of the stage of maturity of each cutting for each variety throughout the season for maximum production.

What is 1/10 bloom? The 1/10 bloom stage is the percent of stems with any flower. It is not always possible to use because of insect damage, disease and short days of the spring and fall. For this reason, height of regrowth of newly developing crown buds found at the base of the alfalfa stem have been correlated with flower development. Many growers prefer to use crown bud development. When one-half the crowns have buds just beginning to show, this is equivalent to early bud stage. In 1/10 bloom alfalfa, crown buds are present on 60% of the crowns and regrowth averages 1/2 to 3/4 inches; at 1/2 bloom crown bud regrowth averages 1 to 2 inches on 80% of the crowns; full bloom alfalfa has crown bud regrowth in excess of 2 inches on every crown.

#### Control Yield and Stand Reducing Diseases With Proper Management and Varieties

The effect on yield reduction by diseases is very difficult to determine. Only when we see stands eliminated and an obvious effect on plant vigor do we attribute yield reduction to diseases. Plant breeders, pathologists and entomologists have been able to find resistance to many diseases and insects, but the development of a "perfect variety" with resistance to all the pests and diseases is almost an impossible hope. I have been in alfalfa

fields where phytophthora root rot, southern anthracnose, bacterial wilt, alfalfa dwarf, stagonospora root rot, crown rots, root knot nematodes, common leaf spot, pea aphids and yellow striped armyworm were all taking their individual and collective toll. Improvements have been made in varietal resistance, especially since 1954 when phytophthora root rot was first identified as a serious stand depleting disease. I will not discuss all of the diseases of alfalfa. For a complete discussion see U.C. Circular 485 and 1971 Proceedings, California Alfalfa Production Symposium.

Phytophthora root rot is the most important disease in California, causing death of whole stands at the end of irrigation runs or in wet, poorly drained fields. Water in excess of field capacity is necessary for the fungus to reproduce and to attack alfalfa roots. It will not attack other crops since this race is specific to alfalfa. Often the disease occurs on sandy, well drained soils, but usually these soils have compacted layers or lenses with textural differences that prevent rapid drainage. Many severe phytophthora infections have been reduced by changing irrigation practices to minimize the amount of free water in the soil. This may involve reducing the quantity of water applied per irrigation, increasing the number of irrigations, or increasing the flow of water in an individual check and shortening the length of the runs, making drains at end of checks, preplant subsoiling, or a combination of practices.

Since Lahontan was introduced in 1954, it has been the variety with the most tolerance to phytophthora root rot available and consequently has been planted on the heaviest and most poorly drained soils in the central valley. However, on well drained soils there is no need to plant Lahontan since many other well adapted varieties with less phytophthora resistance will out-yield Lahontan. Fortunately, new varieties from all dormancy groups with an increased tolerance to phytophthora root rot and greater yielding ability are being released.

Rhizoctonia root canker and summer flooding injury (scald) cause early death of alfalfa plants in the hot desert areas of southern California. Although the cause of these diseases are different, they both can be minimized by reducing the time that roots are saturated. Plants have root damage when soil temperatures at a 2 inch depth reaches 91 to 98°F and the soil remains saturated for over 12 hours, with increasing damage with increasing temperatures and time of saturation. Damage from scald can be minimized or eliminated through a very careful water control program so that soils are not saturated more than 12 hours. Newly mowed plants are more subject to scald than those with one to three weeks regrowth. Crown damage from wheel traffic prior to irrigation causes death of plants in the tracks in less than a week after flooding.

There are other diseases that deserve attention. None, however, are more serious in depleting stands, and none are so favorably affected by change in management practices.

#### Maintain An Adequate Insect Control Program

Like diseases, varietal resistance is probably the ultimate means to control insects. Because of a continuous breeding program by plant breeders, the spotted alfalfa aphid which caused about \$12 million per year damage in the mid 50's, is no longer a problem. Other insects that are an economic threat are the alfalfa weevil, the pea aphid, alfalfa caterpillar and the western striped armyworm. Varietal tolerance, not complete resistance, is available for assistance in controlling the pea aphid. This is a valuable added characteristic that plant breeding has brought and often makes chemical control unnecessary.

The Egyptian alfalfa weevil is the major insect threat to alfalfa production in California. The present status of breeding for resistance to this pest is discussed in these proceedings. A low level of tolerance is all that has been found to date, and a combination of resistance, biological and chemical control will be needed in the future.

Growers can reduce their yield by neglecting timely control for the alfalfa weevil and other insects which cause an economic loss. Losses in the first cutting from the Egyptian alfalfa weevil in Yolo County have been documented as varying from 1/2 ton to 1 ton per acre. Pea aphid damage has reduced yields up to 1 ton per acre in late August and early September in the San Joaquin Valley. The alfalfa caterpillar, western yellow striped armyworm and the beet armyworm can cause similar yield losses if uncontrolled.

Growers should be aware that varieties do differ in their insect resistance, that new strains or races of insects do develop that will attack previously resistant varieties. Recommendations on economic levels of insect control are available from the University of California. By using a chemical that is less harmful on beneficial insects, costs can be reduced. Strip cutting or leaving levees uncut will encourage beneficial insects, and can reduce insecticide costs.

### Practice Good Weed Management

Many weed problems can be traced to poor seedbed preparation, poor irrigation practices, and improper cutting schedules. If your management practices favor weed growth rather than alfalfa development, the use of chemical weed control will only be temporary. Management is the key to successful weed control in seedling and established stands.

Cultural control of weeds in seedling alfalfa. Preirrigating seedbeds that have been prepared early bring up many weeds that can be disked under. Often several diskings can take place before planting. Seedlings that germinate and develop rapidly due to shallow planting, warm temperatures and adequate irrigation, usually are relatively weed free. Poor conditions such as dry seedbed, crusting, and compaction of the soil surface will result in a thin and weedy stand because of the lack of alfalfa plant competition. Adequate soil fertility is essential for providing good alfalfa competition. Many growers feel that a small quantity of complete fertilizer assists in establishing stands. Phosphorus and potassium deficiency certainly will reduce vigor, and when adequately supplied will produce healthy, vigorous alfalfa plants.

If weeds do become a severe competitive problem in new seedling stands, mowing or shredding the weeds just above the young alfalfa plants temporarily stunts the weeds and gives the alfalfa a chance to compete. When chemical control is necessary, a timely application is often the key to success. Consult weed control recommendations of chemical companies and the University of California for specific chemicals to use for specific weeds.

Established Stands. Weak alfalfa plants brought on by compaction, disease, irrigation when there is no cover from regrowth, early cutting which depletes root reserve, reduces vigor and slows regrowth, moisture stress immediately after cutting, all contribute to poor weed control. Stand loss from phytophthora root rot and other diseases allow weeds to replace dead alfalfa. Quality is reduced by the presence of weeds, and price differences for high quality alfalfa hay often justify the use of chemicals.

Many weed problems can be solved by proper management without chemicals. Poor irrigation practices and improper cutting schedules together probably account for most of our weed problems. I have seen alfalfa stands change to weedy fields in less than one year by excessive irrigation that provides a medium for phytophthora root rot to develop. On the other hand, improper timing of irrigation can also bring weed establishment. The most frequent offense occurs when alfalfa stresses after cutting and water is applied immediately after bales are removed when there is no regrowth to cover and shade the ground. This practice will bring watergrass and pigeongrass very rapidly. Frequent cutting in the bud or more immature stages will also reduce the vigor of the alfalfa and prevent regrowth at a rapid enough rate to compete with the weeds.

Whether or not grazing aggravates or reduces weed problems is sometimes debated. Wet fields should never be grazed because of the effect of compaction. Grazing, if done, should be done in such a manner as to minimize the time animals are on any particular piece of ground. A single rapid grazing should not effect alfalfa vigor, subsequent yields, or weeds if it is used as a harvest. Never graze repeatedly, or before there is at least 10-12 inches of regrowth in the fall.

### Summary

Higher yields than are now usually obtained are possible on most soils now producing alfalfa. Growers who are now obtaining 10 to 13 tons per acre are those willing to invest management time, apply available technology, and reorganize and change the important factors that limit alfalfa yield. Top production cannot be obtained by visiting the field only when it is ready to cut. Constant attention and awareness of irrigation needs, damaging insect infestations, potentially disastrous disease buildup, stage of development of the

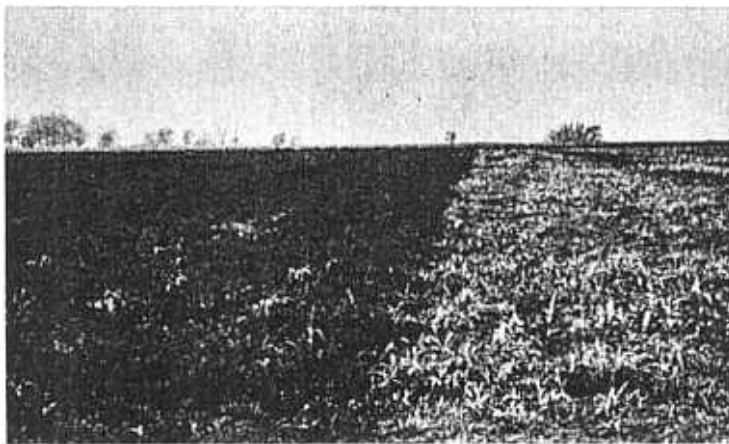
alfalfa in relation to needed irrigation, the fertility status of your alfalfa, and the general overall vigor of your alfalfa stand will pay dividends in increased production and make alfalfa a profitable crop.



Standing water indicates poor soil structure and low infiltration.



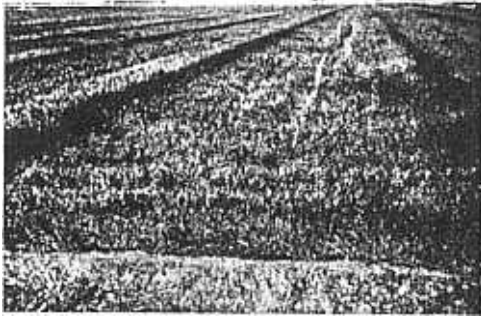
No regrowth after bales removed indicate last irrigation too far before cutting. 5-8 days production lost.



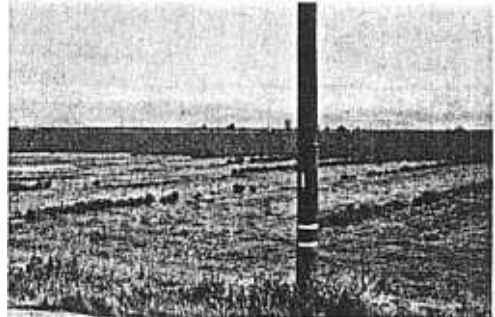
The death and poor vigor of variety on right at end of first year indicates varietal differences in phytophthora root rot resistance and adaptation to heavy soils.



Grazing in fall (left) reduced vigor and allowed weeds to develop. Field on right was not grazed.



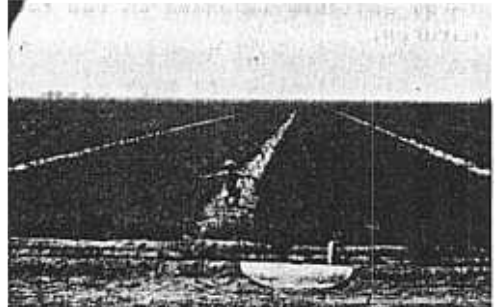
Irrigation runs that were too long caused over irrigation and death of alfalfa from phytophthora root rot.



Alfalfa only on levees and weeds at end of check indicates phytophthora root rot. A drain at end of check would eliminate 15% potential yield loss



Well designed system. No high spots, water advancing uniformly indicates side fall less than 0.1 foot between levees. Note low levees and seeding across levees.



Levee not seeded means 15% lost production in 35 foot checks.



Well made surface drain at end of checks will remove excess water and allow alfalfa to survive. Weeds should be controlled with herbicide.