The Establishment and Management of Alfalfa in Central Oregon

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THE ESTABLISHMENT AND MANAGEMENT OF ALFALFA IN CENTRAL OREGON

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INTRODUCTION

Alfalfa is an extremely important crop in the agricultural economy of Central Oregon. Some of the alfalfa is fed in livestock operations on the farms where it is produced, but most of it is sold as baled hay for use in other parts of the state and region.

Annual yields of 4 to 5 tons of hay per acre have been considered to be very good. However, if proper establishment and management practices are conscientiously applied, much higher yields are possible. Studies conducted at the Central Oregon Experiment Station, Redmond, have clearly shown that yields greater than 8 tons of hay per acre per year are obtainable (Table 1).

Table 1. Yields of alfalfa test varieties grown at the Central Oregon Experiment Station, Redmond, 1970-1974.

	Air-dry hay, tons/acre					
Variety	1970	1971	1972	1973	1974	average
Scout	7.63a-d*	8.16a-c	7.81a-c	5.86a	5.48ab	6.99
Washoe	6.32e	8.04a-d	7.63bc	5.48a	4.84a-c	6.46
Mark II	8.28ab	8.02a-d	8.19ab	5.64a	5.23ab	7.07
Ladak	7.96a-c	8.84a	7.05c	5.06a	5.01a-c	6.78
Vernal	7.88a-d	7.95a-d	8.30ab	5.72a	5.78ab	7.13
Cayuga	7.01cd	7.64b-f	8.22ab	5.71a	5.57ab	6.83
Narragansett	8.00a-c	7.42b-g	7.82a-c	6.00a	5.36ab	6.92
Dawson	7.54a-d	7.01d-g	8.10ab	5.45a	5.22ab	6.66
Saranac	8.50a	7.31c-g	8.42a	6.08a	5.73ab	7.21
Iroquois	8.04ab	8.09a-c	8.36ab	5.92a	5.75ab	7.23
Titan	7.72a-d	7.83a-e	7.89a-c	5.44a	5.96a	6.97
Apex	7.97a-c	8.30a-c	8.09ab	5.48a	5.18ab	7.00
Alfa	8.14ab	8.43ab	8.12ab	4.72a	4.70bc	6.82
Golden Gro	8.05ab	7.42b-g	8.36ab	5.48a	4.96a-c	6.85
NK919	8.30ab	7.00d-g	7.82a-c	5.63a	4.97a-c	6.74
Resistador	7.35b-d	6.49g	8.21ab	5.64a	4.02c	6.34
Promor	7.93a-c	6.83e-g	8.05ab	5.97a	5.19ab	6.79
Haymor	7.44b-d	6.64fg	7.92a-c	5.52a	5.11ab	6.53
Ranger	6.91de	6.77fg	7.62bc	5.71a	5.48ab	6.50

*Values within a year column followed by different letters are significantly different at the 5% level by Duncan's New Multiple Range Test.

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ESTABLISHING THE STAND

The successful establishment of a good stand of alfalfa is practically guaranteed if several factors are taken into consideration, and proven procedures are followed.

SOIL CONDITIONS

Soil Testing

The best way to determine soil fertility levels is to use a soil test. Soil tests should be taken not only before planting but throughout the life of the stand to maintain soil fertility at an optimum level for maximum yields. The cost of a soil test is insignificant in comparison to the loss in yield which might occur if nutrients become limiting.

Fertilizers

When alfalfa is harvested, a continuous depletion of mineral nutrients occurs. The approximate amounts of nutrients removed each year by 5 tons of alfalfa hay are shown in Table 2. Unless maintenance fertilizer is applied, it is likely that one or more nutrients will become deficient on soils that are cropped for any length of time.

Table 2. Plant nutrients removed by 5 tons of alfalfa hay.

Element	N	P	K	Ca	Mg	S
Removal, lb/acre	250	25	250	175	30	25

Adapted from Rhykerd, C. L., and C. J. Overdahl (11).

Nitrogen (N) is one of the elements that is utilized in greatest amounts by alfalfa. If the alfalfa is effectively nodulated with N-fixing bacteria (*Rhizobia*), enough N is fixed from the atmosphere to meet the requirements of the plants.

In Central Oregon, however, it is not unusual for farmers to apply N fertilizer at the time of seeding alfalfa or on established stands. If proper establishment and management practices are neglected, the plants and *Rhizobia* may be stressed by adverse soil and/or moisture conditions, and N fixation will decrease or stop completely. Under these circumstances, it is necessary to supply part or all of the required N through application of N fertilizer. It is noteworthy that alfalfa yields in excess of 8 tons of hay per acre (Table 1) were produced at the Central Oregon Experiment Station without application of N fertilizer. The practice of routinely applying N fertilizer at the time of seeding alfalfa is not recommended, since this may interfere with normal nodulation of the plants.

Phosphorus (P) is involved in many essential processes in plants. Growth of alfalfa plants is slow on a soil low in P, and yields may be much lower than the potential maximum obtainable if P levels in the soil were adequate. A soil test reading of 15 ppm P (Olsen Bicarbonate Method) (8) is considered to be satisfactory for maximum growth of alfalfa in Central Oregon. In a 1974 soil-test survey of 42 Central Oregon alfalfa fields, only 19 (45.2%) had readings of 15 ppm or greater. Eight ranged from 11 to 14 ppm and 15 ranged from 5 to 10 ppm. This indicates that 54.8% of the alfalfa production in the area might be improved by application of P.

Phosphorus fertilizer can be applied before seeding, during seeding, or broadcast on the established stand. Where soil test levels are below 15 ppm, it is advisable to plow down 40 to 80 pounds of P per acre, depending on the soil test, before seeding. It can be applied most effectively during seeding by banding 1 inch below the seed.

The concentration of potassium (K) is higher in alfalfa than any other mineral element except nitrogen. Potassium is essential for many plant processes and promotes the development of hardiness for over-wintering. If sufficient K is not available in the soil, alfalfa stands rapidly thin out and are invaded by grasses and weeds. A soil test reading of 150 ppm K (1:20 NH_4OAC method) (12) is considered to be adequate for maximum production of alfalfa in Central Oregon. In a 1974 soil-test survey, five (11.9%) out of 42 fields ranged from 76 to 116 ppm K. On such fields, it is necessary to apply 100 to 200 pounds of K per acre at the time of seeding or to top-dress with the same amount of K fertilizer to maintain productivity and persistence of the stand.

It is necessary to apply sulfur (S) on most soils in the area. While only 25 pounds of S are required to produce 5 tons of alfalfa hay, S (as SO_4) is subject to leaching from most Central Oregon Soils.

Consequently, the following annual applications of S per acre should be made: loamy sand soils: 100 pounds; sandy loam soils: 80 pounds; loam soils: 50 pounds. It should be applied in the fall or spring and early summer, preferably in two, 50-50 split applications to minimize loss due to leaching. On most soils it should be applied as gypsum or as contained in ordinary superphosphate so that the soil pH is not lowered, as would occur if elemental S were to be applied.

Liming

Alfalfa and Rhizobia are extremely sensitive to soil pH. A soil pH range of 6.5 to 7.5 is ideal for growth of the plant. It is also the range in which N fixation occurs at the highest rate. Soil acidity should be corrected by applying the rate of lime recommended by a soil test. Since lime is slow to react with the soil, it should be applied at least 6 months before seeding. One of the best methods of applying lime is to broadcast 50% of the amount to be applied on the soil surface before plowing. The remaining 50% is applied after plowing and is disced into the soil. This procedure helps to mix the lime with the soil throughout the major rooting zone of the alfalfa.

In correcting soil acidity for the alfalfa and Rhizobia, liming also increases the decomposition of organic residues by microorganisms, which consequently results in the release of plant nutrients. Liming also increases the availability of P and molybdenum (Mo), and decreases the solubility of iron (Fe), aluminum (Al), and manganese (Mn). In some soils, the high concentration of Al and/or Mn under acid conditions may result in poor growth of alfalfa. Molybdenum is essential in the nitrogen-fixation process and may limit production on some Central Oregon soils under acid conditions (3, 4, 5, 7, 11, 14).

Seedbed Preparation

The seedbed should be moist and firm, with some looseness at the surface for coverage of seed. A firm seedbed maintains soil moisture for seedling roots. Many seedlings die in a loose seedbed with large air spaces because their roots die when they reach the air spaces. Moisture is lost more rapidly from a loose seedbed than from a firm one. It is especially necessary that sandy soils be firm because they lose moisture rapidly if they are loose. Irrigation before seeding assists in firming the seedbed and enhances the effectiveness of inoculation.

INOCULATION

One of the major problems in establishing and maintaining productive alfalfa stands in Central Oregon is the failure to achieve effective nodulation of the plants. If alfalfa is effectively nodulated, yields are increased, quality is improved, protein content is higher, and plant survival is greater. Without nodulation, the plants suffer from N deficiency, yields decrease, and the stand rapidly degenerates. Therefore, it is absolutely essential to inoculate alfalfa seed with a vigorous and effective strain of *Rhizobia* to nodulate the plants so that N fixation can occur at a high rate.

If a few simple steps of the inoculation procedure are followed, successful nodulation of alfalfa is usually obtained.

1. Use only fresh inoculants specifically for alfalfa that have been stored under refrigeration until the time of planting. If the inoculant has not been stored under refrigeration where it is sold, do not purchase it. Do not use inoculants after the expiration date of the package. Sufficient numbers of viable *Rhizobia* are present in the package for about 4 months from time of packaging if kept under refrigeration, and for only 3 to 4 weeks without refrigeration. It is best to reinoculate pre-inoculated seed, because the conditions under which the seed was stored usually are not known. Use two or three times the amount of inoculum specified on the package. It is not possible to over-inoculate.

2. In spite of the directions usually found on inoculant containers, dry application of inoculum is not recommended, because only about 20% of the dry inoculum adheres to the seed. Also, survival of the *Rhizobia* on the seed is less if applied dry. A special slurry method of inoculation should be used to insure maximum survival of the *Rhizobia* on the seed. Suspend the inoculum in about a quart of 25% sugar solution for each 100 pounds of seed. Just before planting, mix the slurry and seed together thoroughly, before placing in the seeder box. If the seed-slurry mixture is too moist for planting, add small amounts of finely ground limestone to soak up the excess moisture. With this method of inoculation, it is best to recalibrate the seeder to be certain the desired amount of seed is being planted.

3. Inoculate in the shade--never in direct sunlight--because the ultra-violet rays in sunlight kill the Rhizobia.

4. Plant the seed as quickly as possible after inoculation (2, 4).

RATE OF SEEDING

Twelve to 15 pounds of seed per acre are sufficient to obtain a good stand of alfalfa. Use only good seed, having high percentages of purity and germination (4, 14, 17, 20).

METHOD OF SEEDING

Basically, two machines are available for planting alfalfa. Probably the most used is a grain drill with a legume-seeder attachment or corrugated roller for compaction. Optimum coverage of the seed ranges from ¼ to ½ inch on heavy soils and ½ to 1 inch on sandy soils. A cultipacker seeder can give excellent results because seed coverage is nearly optimal and the seedbed is firmed. The cultipacker works well on all soils except if used on a powder or dry sandy seedbed where the soil may roll and result in excessive coverage of the seed. An advantage of the grain drill is that fertilizer can be banded below the seed in the same operation. Also, a grain drill serves to plant other crops (4, 14, 17).

IRRIGATION

Dry soil conditions kill more alfalfa seedlings than any other cause. If the seedbed has been properly prepared and is moist, irrigation after planting for plant emergence is unnecessary. If possible, irrigation after emergence should be withheld until the plants are 3 to 4 inches tall and have three or more true leaves. On some soils it may be necessary to irrigate to soften any crust formation to permit seedling emergence. Frequent irrigations may be necessary on sandy or saline soils to prevent moisture stress of the seedlings (16).

Emerging seedlings are extremely sensitive to soil water conditions. Young seedlings have shallow roots and are severely stressed during warm weather with drying winds. Irrigations should be applied so as to maintain the moisture conditions at slightly less than field capacity. Withholding irrigation in an attempt to force the plants to develop deep roots is not recommended (9, 16).

TIME OF SEEDING

In Central Oregon three climatic factors reduce the chances of obtaining a satisfactory stand of alfalfa:

1. Frost during the period of growth between emergence of the seedlings and the formation of true leaves.
2. High temperatures during July and early August.
3. Frost heaving of small plants during fall and winter.

The two most opportune times for seeding alfalfa in the area are in the spring and late summer.

Spring seedings made during the first week of June usually are not damaged by frost and become established well enough to survive the high temperatures of July and August. Spring seedings must be made either with a herbicide or a companion crop to control weeds. On light sandy soils, 2 pounds per acre of EPTC (Eptam) herbicide applied according to recommendations provides good control of annual grass and broadleaf weeds in establishment of alfalfa. Use 3 pounds per acre on heavier soils (1). Spring seedings made with a herbicide usually may be harvested in the late summer and will yield 1 to 1.5 tons of hay per acre. Although a companion crop provides some income as grain or hay, it may compete so severely with the alfalfa seedlings for water, nutrients, light, and space that the alfalfa stand would be greatly reduced. For this reason, the use of companion crops to control weeds in spring-seeded alfalfa is not recommended in Central Oregon.

Late summer seedings made before August 15 usually become established well enough to resist heaving by frost in the following fall and winter. Annual weeds usually are not a problem because weather and light conditions at this time discourage their growth. The seeding may be made in the stubble of an oat or barley hay crop, thereby permitting some production to be realized from the field in the alfalfa seeding year.

MANAGING THE STAND

In some respects, management of alfalfa for maximum production and persistence in Central Oregon is even more difficult and more critical than in other northern areas of the United States. Dry, hot summer conditions require careful and correct irrigation practices. Cold winters without continual snow cover and with freezing and thawing conditions make fall management for development for hardiness especially critical. The soils are complex, with wide variation in depth, drainage, texture, water-holding capacity, and fertility, making it very difficult to achieve and maintain correct soil conditions for alfalfa.

If the best available practices are diligently followed, effects from these environmental factors can be minimized. High yields of 6 to 8 tons of alfalfa hay per acre per year from long-lived stands are possible in Central Oregon.

IRRIGATION

One of the major problems in the management of alfalfa in Central Oregon lies in achieving proper irrigation. Much of the alfalfa grown in the area is not irrigated properly. On a given summer day any number of fields or parts of fields can be found in which the alfalfa plants are wilting or near the wilting point. After each cutting, bales of hay are left on fields for excessive lengths of time, during which no irrigation can be applied. This practice not only retards regrowth of the plants, but also kills plants by smothering and lack of sunlight beneath the bales.

Three factors must be taken into consideration in determining when to irrigate alfalfa: water availability, soil water-storage capacity, and crop needs. If water is available to irrigate, crop needs are then most important.

Central Oregon soils generally are shallow and have low water-holding capacities. Moisture conditions in such soils can change rapidly. Consequently, irrigations should be made when available soil moisture is about 50% of field capacity (13).

Two practical methods are available to determine the amount and timing of irrigations required for optimum production of alfalfa. They are based on the use of pan evaporation (ET_p) rates and tensiometers.

If the soil water-storage capacity and effective rooting depth of the plants are known, ET_p rates obtained at the Central Oregon Experiment Station (Figure 1) can be used to predict irrigation needs. Available water-storage capacities for major soils in Central Oregon are shown in Table 3. The effective rooting depth of alfalfa varies with soil depth, but alfalfa obtains most of its moisture from the top 2 feet of soil.

Table 3. Available water-storage capacities of major soils in Central Oregon.

Soil type	Avg. available water-storage capacity	Location, county
	in/ft	
Agency sandy loam	2.2	Crook, Deschutes, Jefferson
Agency loam	2.2	Crook, Deschutes, Jefferson
Deschutes loamy sand	1.5	Crook, Deschutes
Deschutes sandy loam	1.7	Crook, Deschutes
Lamonta loam	1.7	Crook, Deschutes, Jefferson
Madras sandy loam	2.2	Deschutes, Jefferson
Madras loam	2.3	Deschutes, Jefferson
Metolius sandy loam	2.4	Crook, Deschutes, Jefferson
Ochoco sand loam	2.4	Crook
Prineville sandy loam	1.6	Crook
Willowdale loam	2.9	Jefferson, Wasco

Adapted from Simonson, G. H. and M. N. Shearer (13).

As an example, a Deschutes loamy sand can store 1.5 inches of water in each foot of the soil profile. If the soil is 2 feet deep, the maximum it can hold is 3 inches of water. In a shallow, light-textured soil such as this, it is necessary to irrigate when the soil moisture reaches 50% of field capacity, or 1.5 inches of available water. The ET_p rate between July 22 to 31 is about 0.31 inches of water per day. At this rate, evapotranspiration (ET) would remove 50% of the water from the profile in 5 days. Therefore, the maximum interval between irrigation sets would be 5 days--as long as the ET_p rate remained at 0.31 inches per day. With longer intervals between sets, the plants would be under moisture stress after 5 days, and yields would be reduced. Each irrigation set should apply 1.5 inches of water to fill the soil up to its water-storage capacity.

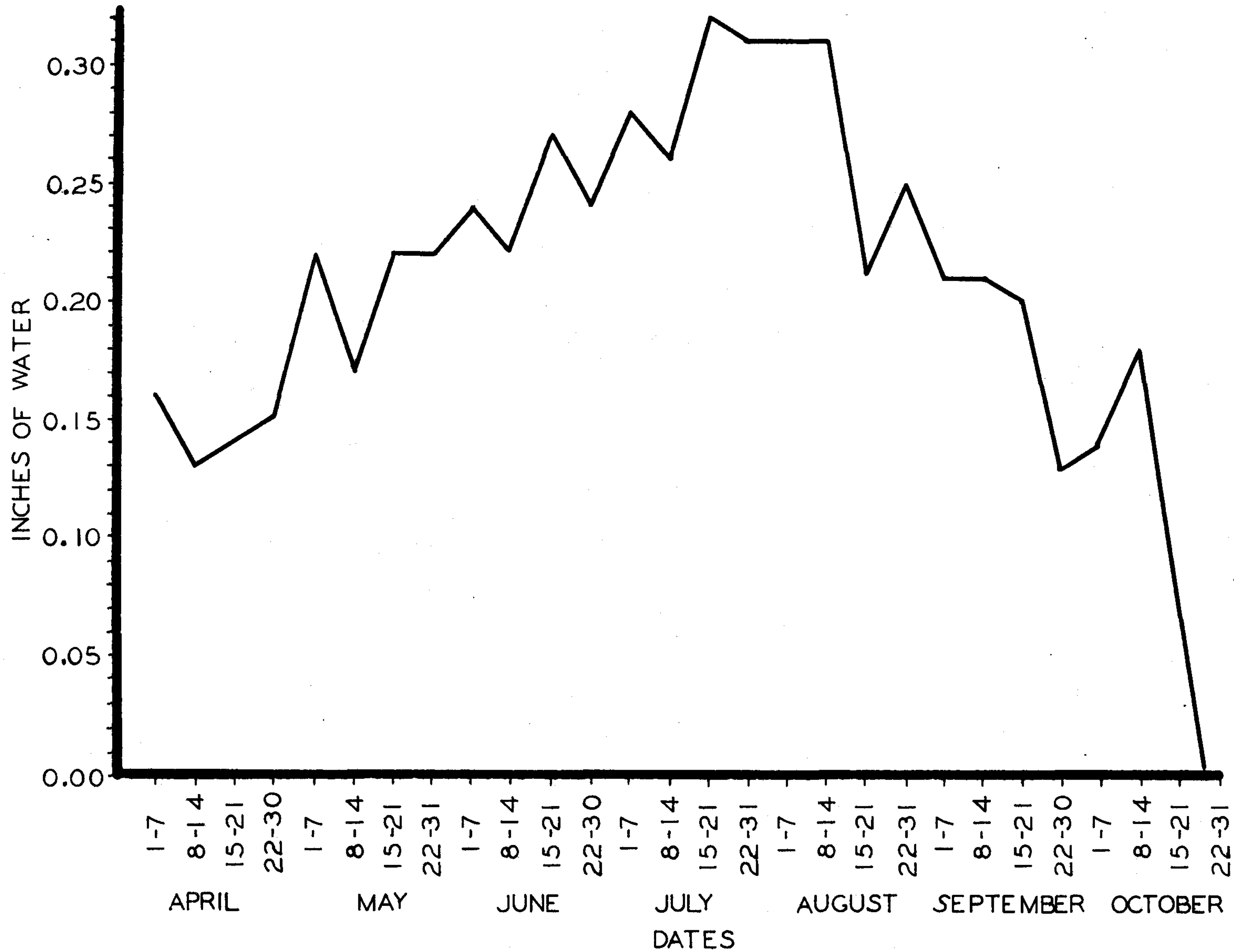

Figure 1. Average (1970-1975) pan evaporation rates at Central Oregon Experiment Station, Redmond.

From Figure 1 it is clear that intervals between irrigation sets should vary as the ET_p rates change during the growing season. It should be noted that ET_p rates correlate closely with ET rates from complete crop cover. Obviously, ET rates are lower from a developing crop such as in the early spring or after a cutting of alfalfa is made. Consequently, the ET_p values used to schedule irrigations during such periods of growth should be adjusted downward by using an estimated factor of 0.85. For example, the ET_p rate for June 1 to 7 is 0.24 inches per day. Since the alfalfa crop is developing during this period, the actual ET would be less than that from a complete crop cover. The adjusted ET_p rate for this growth period would be 0.85 x 0.24 = 0.20 inches per day. At this rate, the Deschutes loamy sand soil used in the example above, would lose 50% of its available water in 7.5 days (1.5/0.20=7.5). Irrigations during this growth period would be scheduled every 7.5 days and would apply 1.5 inches of water per set.

A tensiometer, which measures soil water suction, can also be used to schedule irrigations. When the instrument registers a suction limit determined for a particular crop, irrigations are made to bring the soil up to its water-storage capacity. The soil water suction at which water should be applied to alfalfa growing on a deep, well-drained, fertile soil is 1.50 bars. More research needs to be conducted in Central Oregon to determine the suction limits for alfalfa growing on the shallow soils of the area (6).

Care should be taken to apply only the amount of water that can be held in a soil. Not only is it inefficient to apply more water than can be stored in a soil, but over-irrigation is harmful to alfalfa growth (Figure 2) and will leach plant nutrients from the soil.

A common practice in the area is to use long sets under sprinkler irrigation of 12 to 24 hours and long intervals of 10 to 12 days between sets. Depending upon the soil, this method can be extremely detrimental to the alfalfa. During and shortly after irrigation, the soil may be at the saturation point. By the time of the next irrigation, available soil moisture may be depleted to the wilting point. Any time the wilting and/or saturation points are reached, there is a reduction in hay yield and quality (10).

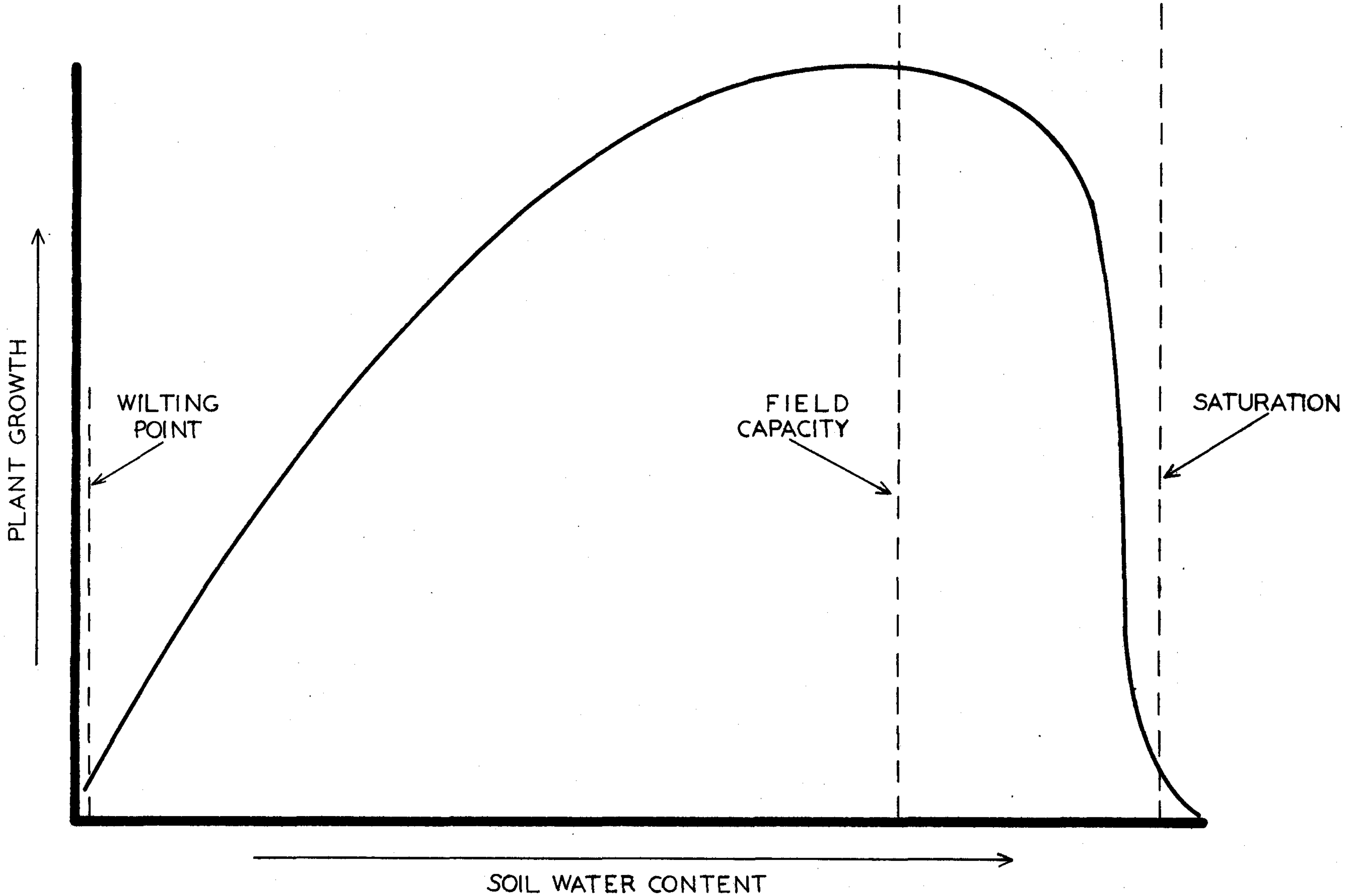

Figure 2. The relation of alfalfa growth and soil water content. Adapted from Peterson, H. B. (10).

Alfalfa fields should be irrigated up to field capacity before winter sets in, so the plants have sufficient moisture to live on over winter.

FERTILIZATION OF THE ESTABLISHED STAND

Soil tests should be taken throughout the life of the stand in order to maintain soil fertility at an optimum level for maximum yields. Top dressing with P, S, and K (if soil tests indicate a need) should be done each year. At the Central Oregon Experiment Station, annual applications of 35 pounds of P and 100 pounds of S per acre have proven to be adequate to maintain productivity and persistence of alfalfa stands. Oregon State University publishes Fertilizer Guides that are periodically revised as information is refined by research. Guides are available at county Extension offices for use by farmers to determine their individual maintenance fertilizer needs.

TIME OF CUTTING

An understanding of the trend of available carbohydrate root reserves in alfalfa is essential for its correct cutting management. The root reserves are utilized by the plant to produce new growth and energy for many of its life processes. Storage and use of the reserves follows a cyclical pattern.

When growth begins in the spring or after the plant has been cut or grazed off, carbohydrate root reserves are used to produce new top growth. The reserves continue to be drawn upon until the plant has produced about 8 inches of top growth (succulent stage). With this amount of top growth, enough carbohydrates are formed by photosynthesis so that the root reserves begin to be replenished. Maximum storage of available carbohydrates in the roots is reached at about full bloom.

When alfalfa is cut at the full-bloom stage, high root reserves have been accumulated and, consequently, regrowth is more rapid. Productivity and persistence of the plants are more easily maintained. Cutting at full-bloom also permits the plants to recover from the effects of stress due to over-wintering, improper irrigation, or disease.

Although delaying cutting until full bloom is best for the plants, the hay that is produced is of lower quality than that produced by cutting at earlier maturity. If very winter hardy, bacterial wilt-resistant varieties are used, it is possible to cut early for better hay quality without reducing the productivity and persistence of the stand. The 10% bloom or first-flower stage is the optimum time to cut alfalfa (Figure 3). Even though root reserves are not at a maximum, they are high enough that the plants are not damaged. The highest yield of nutrients, protein, and minerals is obtained at this stage.

Cutting according to plant maturity takes into account differences due to varieties, locations, and years. In this sense, it is more satisfactory than cutting according to a calendar date or by time interval. It is also more satisfactory than cutting according to development of new crown shoots. New shoots do not develop regularly at any specific time, and may be brought on by irrigation after severe moisture stress or when top growth lodges and crown buds are exposed to sunlight. Development of new crown shoots should be taken into consideration, however, on all cuts and especially the first one in the spring. In Central Oregon, frosts can occur at any time that would stop the flowering process and eliminate it as an indicator of when to cut. If crown shoots begin to elongate to the point where they would be cut off if cutting were to be delayed further, the stand should be harvested. No matter when a cut is made, the hay should be removed from the field as soon as possible and irrigation should begin.

SPRING MANAGEMENT

Early spring management is very important in maintaining productivity and persistence, especially if the stand has been damaged during the winter. If a winter-damaged stand is cut too early, yields of subsequent harvests will be reduced and the stand will rapidly degenerate. Winter-injured stands of disease-resistant varieties usually recover if the first cut is delayed until full bloom. Subsequent cuts may be made at 10% bloom. If the stand has not been damaged during the winter, all cuts should be made at 10% bloom, unless crown shoots elongate excessively before that time.

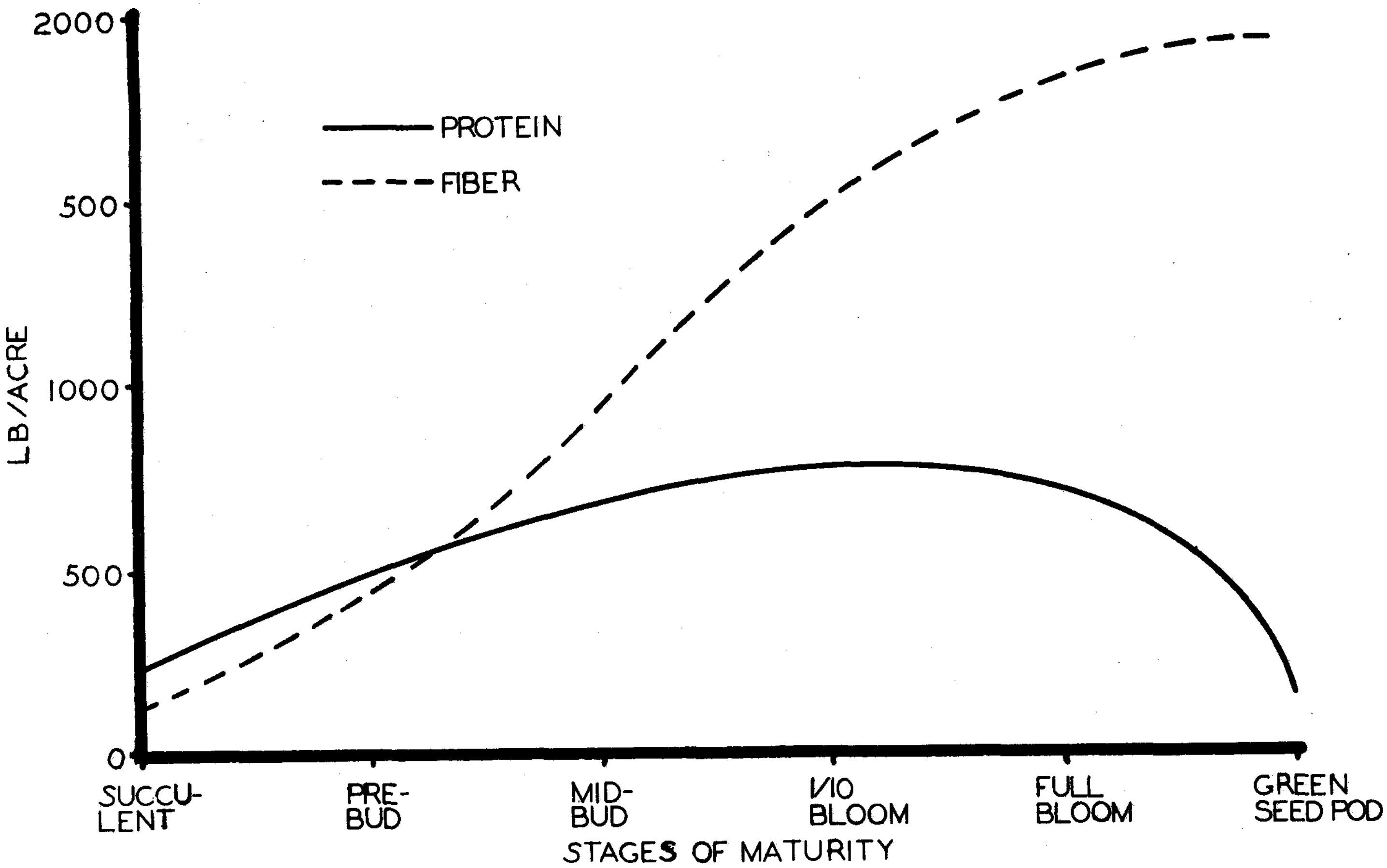

Figure 3. Yields of protein and fiber in alfalfa at different stages of maturity. Adapted from Van Riper, G. E., and Dale Smith (19).

Due to the warm periods followed by low temperatures that occur during the winter in Central Oregon, alfalfa stands usually sustain some winter injury. Injured stands that must be cut at first flower every cutting, to meet quality requirements in saleable hay, probably will need to be reseeded every 5 years.

FALL MANAGEMENT

In Central Oregon, 4 to 6 weeks before the first killing frost is a critical period in the management of alfalfa. Alfalfa should not be cut during this time. Eight to 10 inches of top growth are needed during this entire period to produce sufficient carbohydrates for storage in crowns and roots. The stored reserves are used to develop cold resistance, to live on during the winter dormant period, and to begin regrowth in the spring. About 50% of the stored reserves are used during the winter. If alfalfa goes into winter with a low level of reserves, winter survival is lessened and the number of crown buds and rhizomes that produce regrowth in the spring is reduced.

On the average, the first killing frost occurs in Central Oregon about September 15. Cutting after the first killing frost is not as hazardous as cutting before it. Root reserves are usually at a high level by this time. If a stand is cut in the fall, a tall stubble should be left to catch and hold snow for insulation during the winter. Continual grazing by cattle or sheep during the fall and winter is not advisable (14, 15).

SUMMARY

Yields of alfalfa hay can be increased greatly--possibly doubled--in Central Oregon if proven establishment and management practices are applied. In summary, the practices may be divided into the following major categories, none of which can be neglected if maximum, sustained production of alfalfa is to be obtained:

SOIL CONDITIONS. Soil tests should be taken before planting alfalfa and throughout the life of the stand. Fertilizer and lime recommendations resulting from the tests should be followed.

The seedbed should be moist and firm, with some looseness at the surface for coverage of seeds. Optimum coverage of seed ranges from ¼ to ½ inch on heavy soils and ½ to 1 inch on sandy soils.

INOCULATION. It is absolutely essential to inoculate alfalfa seed with a fresh inoculum specifically for alfalfa. This ensures that the plants will be nodulated with an efficient strain of Rhizobia that will fix N at a high rate.

RATE OF SEEDING. Use 12 to 15 lb/acre of good seed, having high percentages of purity and germination.

TIME OF SEEDING. Plant either during the first week of June with a herbicide, or in late summer before August 15.

IRRIGATION. One of the major problems in the establishment and management of alfalfa in Central Oregon lies in achieving proper irrigation. If irrigations are applied according to crop needs and soil water-storage capacities, the problem may be eliminated. If irrigations are applied according to a convenient time schedule, the problem will continue.

TIME OF CUTTING. Usually alfalfa should be cut at 10% bloom.

SPRING MANAGEMENT. The first harvest of the season should be delayed until full bloom if the stand has been damaged during the preceeding winter.

FALL MANAGEMENT. Alfalfa should not be cut during the 4- to 6-week period before the first killing frost of autumn.

LITERATURE CITED

1. Appleby, A., D. Rydrych, P. Olson, and R. Burr. 1974. Selective control of weeds in field crops. p. 48. In R. Burr (ed.) Oregon Weed Control Handbook. Extension Service, Oregon State University, Corvallis, Oregon.

2. Burton, J. C. 1972. Nodulation and symbiotic nitrogen fixation. In C. H. Hanson (ed.) Alfalfa Science and Technology. Agronomy 15:229-246. Am. Soc. Agron., Madison, Wis.
3. Gardner, E. H., N. R. Goetze, G. Gross, E. N. Hoffman, T. L. Jackson, M. J. Johnson, D. P. Moore, W. S. McGuire, and V. Pumphrey. 1969. Fertilizer guide for alfalfa. Extension Service Fertilizer Guide. Sheet 20., Oregon State University, Corvallis, Oregon.
4. Goetze, N. R., and H. Youngberg. 1972. Growing alfalfa in Western Oregon. Extension Circular 806. Oregon State University, Corvallis, Oregon.
5. Griffith, W. K. 1974. Satisfying the nutritional requirements of established legumes. p. 147-167. In D. A. Mays (ed) Forage fertilization. Am. Soc. Agron., Madison, Wis.
6. Hagan, R. M., and H. R. Haise. 1967. Soil, plant, and evaporative measurements as criteria for scheduling irrigation. In R. M. Hagan, H. R. Haise, and W. W. Edminster (eds.) Irrigation of agricultural lands. Agronomy 11:577-597. Am. Soc. Agron., Madison, Wis.
7. Dresge, B. B. 1974. Effect of fertilization on winterhardiness of forages. p. 437-451. In D. A. Mays (ed.) Forage fertilization. Am. Soc. Agron., Madison, Wis.
8. Olsen, S. R., D. V. Cole, F. S. Watanabe, and L. A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular No. 939.
9. Peters, D. P., and J. R. Runkles. 1967. Shoot and root growth as affected by water availability. In R. M. Hagan, H. R. Haise, and T. W. Edminster (eds.) Irrigation of agricultural lands. Agronomy 11:373-386. Am. Soc. Agron., Madison, Wis.
10. Peterson, H. B. 1972. Water relationships and irrigation. In C. H. Hanson (ed.) Alfalfa science and technology. Agronomy 15:469-480. Am. Soc. Agron., Madison, Wis.
11. Rhykerd, C. L., and C. J. Overdahl. 1972. Nutrition and fertilizer use. In C. H. Hanson (ed.) Alfalfa science and technology. Agronomy 15:437-465. Am. Soc. Agron., Madison, Wis.
12. Schollenberger, C. J., and R. H. Simon. 1945. Determination of exchange capacity and exchangeable bases in soils--ammonium acetate method. Soil Sci. 59:13-24.
13. Simonson, G. H., and M. N. Shearer. 1971. Intake rates and storage capacities of irrigable soils in Central and Northeastern Oregon. Agr. Exp. Sta. Special Report 324., Oregon State University, Corvallis, Oregon.
14. Smith, Dale. 1962. Forage management in the North. Brown Book Co., Dubuque.
15. Smith, Dale. 1972. Cutting schedules and maintaining pure stands. In C. H. Hanson (ed.) Alfalfa science and technology. Agronomy 15:481-493. Am. Soc. Agron., Madison Wis.
16. Stanberry, C. O. 1955. Irrigation practices for the production of alfalfa. p. 435-443. In USDA yrbk of agriculture: water.
17. Tesar, M. B., and J. A. Jacobs. 1972. Establishing the stand. In C. H. Hanson (ed.) Alfalfa science and technology. Agronomy 15:415-433. Am. Soc. Agron., Madison, Wis.
18. Tisdale, S. L., and W. L. Nelson. 1966. Soil fertility and fertilizers. Macmillan Co., New York. p 128.
19. Van Riper, G. E., and Dale Smith. 1959. Changes in the chemical

composition of the herbage of alfalfa, medium red clover, ladino clover, and bromegrass with advance in maturity. Wis. Agr. Exp. Sta. Res. Report 4.
20. Youngberg, H. 1972. Inoculating alfalfa and clover seed. Extension Service Fact Sheet 184., Oregon State University, Corvallis, Oregon.