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Irrigating Alfalfa in South Dakota

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EC 730

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Cooperative Extension Service • South Dakota State University • U.S. Department of Agriculture

Contents

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Alfalfa performs admirably as an irrigated crop in South Dakota—so well that it is often neglected. When given attention, it can realistically maintain irrigated yields of 6 to 7 T/A each year in most of South Dakota where 1 to 2 T are produced on dryland.

Irrigated land that will produce 100-130 bu corn will produce 5-7 T alfalfa. On poorer irrigated land that produces 50-70 bu corn, one can expect 3-5 T alfalfa.

Alfalfa has higher water requirements for peak yields than most other crops. It may not reach its full potential yield in any part of the state without irrigation.

Alfalfa is produced on 2.2 million acres (dryland and irrigated combined) in every county in South Dakota. By contrast, even when corn is irrigated, it is adapted to only about two thirds of the state. If the marketing problems of transportation and fluctuating prices are overcome, alfalfa could become the state's number one irrigated crop.

Variety Selection

The customary dryland alfalfa varieties may not be the best choices for irrigation.

No single variety has all the characteristics necessary for best results under all conditions (Table 1). For example, we need a winterhardy and drought tolerant variety like Vernal on dryland. But with irrigation on a poorly drained soil, Vernal is not the best choice because it does not have rapid regrowth or phytophthora root rot resistance.

Careful variety selection is often more important for irrigation than for dryland production. Since production costs are greater under irrigation than on dryland, the wrong variety can substantially reduce profits. Additional information on varieties is given in FS 529, Alfalfa varieties for South Dakota.

Table 1. Selected variety characteristics and their importance for dryland and irrigated production.

Variety characteristic	Important for dryland	Important for irrigation
Winterhardiness	Yes	Desirable
Drought tolerance	Yes	No
Common leaf spot resistance	No	Desirable
Bacterial wilt resistance	Yes	Yes
Insect resistance	Desirable	Desirable
Regrowth ability	Not always	Yes
Phytophthora root rot resistance	Seldom	Yes
Seedling vigor	Yes	Yes

Common or South Dakota Common. This category of seed alfalfa does not guarantee varietal purity.

It is of unknown breeding; the buyer cannot predict performance. One sack labeled "common" may be excellent for irrigation, while another one may result in stand loss in 2 years.

"Common" or "South Dakota Common" seed is not a wise choice for irrigation unless the buyer can be **positive** that it originated from a variety known to perform well under irrigation.

Public versus Private Varieties. In the past, most alfalfa varieties were developed and released by state agricultural experiment stations and by USDA. Varieties from these sources are known as "public" varieties.

However, in recent years private industry has gained an active role in breeding and selecting hay varieties. Privately developed varieties are called "proprietary."

When a variety meets agronomically important requirements, it does not matter whether that variety is a public or private release, as long as the grower can be confident that the advertised characteristics of the variety are actually present.

Flemish versus Standard Regrowth Types. In recent years Flemish strains from northern and western Europe have become popular in humid regions and in semi-arid regions where irrigation effectively creates a long growing season.

Flemish types have more rapid regrowth than non-Flemish strains, and are better able to utilize the full growing season when irrigated. Most recent Flemish varieties have improved winter hardiness and disease resistance.

The need for extreme levels of winter hardiness or drought resistance that exists for much of South Dakota is offset to some extent by irrigation. With irrigation, plants can be managed to go into winter with a high level of vigor. Winter injury will be less severe unless frost heaving or ice sheet formation occurs; then differences in winter hardiness probably are not related to survival.

Several standard (non-Flemish) varieties produce well under irrigation. Flemish types may have an edge where growers are pushing for peak production.

However, experiences to date in South Dakota show that several standard varieties are just as productive as Flemish strains. It is appropriate to consider planting some of both, especially where large acreages are irrigated.

A 5-year trial at Redfield (Table 2) showed comparable irrigated production from Iroquois (standard), Vernal (standard), and Saranac (Flemish). In 1974 Iroquois and Saranac yielded better than Vernal which is an excellent dryland variety. There were no real differences in any other year.

In a 20-variety irrigated trial at Nisland, Butte County (Table 3), several standard and Flemish varieties produced a 3-year average of 7.2 T/A. Only four varieties (Vernal, Ladak 65, Iroquois, and Siberian) were substantially less productive than most of the other 16.

The point is that many varieties have high yield potential; it is often more meaningful to select varieties on the basis of other characteristics.

Winter hardiness (and related drought tolerance) and bacterial wilt resistance are more important than minor yield differences.

Wilt resistance is especially important under irrigation where there is often a risk of early stand loss with wilt susceptible varieties. For long life under irrigation, varieties should also be at least moderately winter hardy and drought tolerant.

For soils that are poorly drained or periodically inundated, phytophthora root rot resistance is highly desirable. Some resistant varieties are Agate (Peterson Seed Co.), Apollo (North American Plant Breeders), and Phytor (Northrup-King Co).

On poorly drained soil at Arpan, only resistant varieties, Apollo and Agate, maintained satisfactory stands after two growing seasons (Table 4). Phytophthora root rot organisms were isolated in yellowed and stunted susceptible plants.

Table 2. Yields of irrigated alfalfa varieties at Redfield.

Variety	1973 *	1974 **	1975	1976 ***	1977 ***	Total
			T/A			
Vernal (standard)	3.4	5.4	7.2	5.6	3.8	25.4
Iroquois (standard)	3.8	6.6	7.2	5.6	3.9	27.1
Saranac (Flemish)	3.6	6.5	7.6	5.8	3.8	27.3

*Stand established.
**Only year where real differences in production occurred among varieties.
***Irrigation water shortage resulted in half the normal amount applied.

Table 3. Nisland (Butte County) irrigated alfalfa trial showing 10 of the 20 varieties under test.

Variety*	Source	Winter hardiness and drought tolerance	Bacterial wilt resistance	Phytophthora root rot resistance	Hay yield, 1975-77**	Stand, August 1978
					T/A	%
Vernal (S)	Public, Wisc Ag Exp Sta	High	Resistant	Susceptible	6.7	60
Dawson (S)	Public, Neb Ag Exp Sta	High	Susceptible	Susceptible	7.1	69
Agate (S)	Peterson	High	Resistant	Resistant	7.6	76
Ladak 65 (S)	Public, Mont Ag Exp Sta	High	Resistant	Susceptible	6.5	61
Iroquois (S)	Agway	High	Resistant	Susceptible	6.5	68
Siberian (S)	Foster's Yellow Blossom	Very High	?	Susceptible	5.4	52
J-80 (F)	Jacques	Moderate	?	?	7.5	70
Thor (F)	Northrup-King & Co	Moderate	Resistant +	Susceptible	7.7	77
Americana (F)	Teweles Seed Co	?	Susceptible	Susceptible	7.6	70
Superstan (F)	Teweles Seed Co	Moderate +	Resistant	Mod. resistant	7.8	70
20 variety average					7.2	—

* (S) Standard variety; (F) Flemish variety
** Trial established in 1974

Establishment

By contrast to dryland, irrigated alfalfa is easier to establish. This is especially true in drier parts of the state or during dry spells anywhere.

Three essentials of establishment are (1) seed in a firm seedbed, (2) seed at a uniformly shallow depth, and (3) hold early weed competition to a minimum.

Details on stand establishment are discussed in FS 503, Planting tame pastures and hayland. Additional information specific to irrigation and some suporting data are given below.

Careful **seedbed preparation** pays handsomely in establishment.

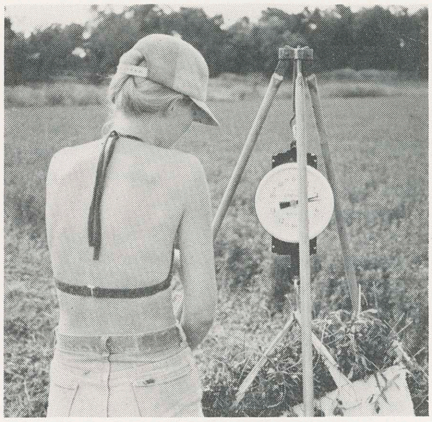
Fall plowing and discing will often permit seeding in early spring, especially on fine textured soils that require weathering to be mellow or on those that have an existing stand of old alfalfa or sod.

Final preparation should destroy germinating weeds, break and level large clods, and leave a firm clean seedbed. A cultipacker seeder will often create such a seedbed. Other seeders may require additional tillage.

Cloddy seedbeds can result in poor stands unless excessive amounts of seed are used. If the seedbed is not firm, air pockets may form, causing young seedlings to lose contact with soil moisture and die.

If weeds are not a problem, seeding with a grassland drill directly into small grain or row crop stubble frequently eliminates the need for seedbed preparation.




Alfalfa production trials are farming on a small scale. Plots are located throughout the state to match soils and climates that growers face. Careful mowing, collecting, weighing, and sampling in the plots insure accurate results which are passed on as variety recommendations.

As with dryland plantings, the best **date of establishment** is early spring, generally about April 15 to May 15. Fields may be irrigated the previous fall.

Late summer establishment (August 1-September 1) can be quite satisfactory. Prepared seedbeds or small grain stubble can be irrigated. Seeding should be done as soon afterwards as possible for rapid germination and sufficient growth for overwintering vigor. Planting as late as September 15 can be successful, but risks of winter kill will increase.

Late fall plantings (after November 1) into dry seedbeds run the risk of germination so early in the spring that seedlings may be killed by frost. Late fall (dormant season) seedings are not recommended for alfalfa.

Companion crops or nurse crops can be used to excellent advantage with new seedings: (1) They provide protection from weeds and supply shade. (2) Small grains used this way can be harvested for hay or grain. (3) Companion crops permit earlier irrigation than would be possible if no companion crop were used.

With flood irrigation, companion crops help to prevent erosion and lessen the "baking effect" that can kill alfalfa seedlings. With sprinkler systems, the added benefit of breaking the impact of water droplets can be important.

To prevent excessive shading or moisture competition, the seeding rate of small grain companion crops should be substantially reduced. Full seeding rates can result in excessive competition and failure of the alfalfa seeding.

The following rates are recommended, depending on soil moisture and weather. The higher rates should be used in anticipation of favorable growing conditions:

- oats, 25-30 lb/A
- barley, 30-45 lb/A
- standard height spring wheat, 25-50 lb/A
- semi-dwarf spring wheat, 30-50 lb/A

Recent **establishment method** trials with irrigation at Brookings compared companion crops and herbicide systems.

The primary yield differences were found in the seedling (first) year. The tradeoffs are readily apparent in Table 5.

Method of establishment did not affect alfalfa yields in following years.

When producers are primarily interested in contracting alfalfa for dehydration or in selling alfalfa hay, a preplant herbicide can obtain more alfalfa the seedling year. When properly done, nearly pure alfalfa can be obtained approximately 10 weeks after planting.

On the other hand, seeding a small grain and harvesting as forage will yield more total forage and be less costly. When a small grain companion crop is planted for forage, protein content of the first harvest will be lower than for pure stands.

Table 4. Arpan (Butte County) irrigated alfalfa trial with Phythophthora root rot confirmed.

Variety	Phytophthora root rot	Hay production, 1977*				Stand evaluation. September 1977**
		1st	2nd	3rd	Total	
		T/A				
Apollo	Resistant	1.8	1.3	1.3	4.4	Good
Agate	Resistant	1.5	1.2	1.2	3.9	Good
Local seed***	Unknown	1.6	1.3	1.0	3.9	Fair—
Weathermaster A-77	Unknown	1.9	1.2	0.8	3.8	Poor
Iroquois	Susceptible	1.7	1.2	0.9	3.8	Poor+
Cossack	Susceptible	1.8	1.1	0.8	3.6	Poor+
Thor	Susceptible	1.5	1.1	0.8	3.4	Poor+
Vernal	Susceptible	1.5	1.0	0.8	3.3	Poor+

*Planted April 1976. All varieties had excellent stands in 1976.

**Good = Good stand, appears healthy; Fair = Good stand, 0-20% plants yellowed, somewhat stunted; Poor = Stand thinning, 20-50% plants yellowed, some stunted.

***The "local seed" was from an old nearby field thought to have originated from Cossack.

Table 5. Irrigated alfalfa trials using four establishment methods at Brookings.*

Establishment method	Seeding year weed-free hay	Plus grain harvested	Plus straw harvested
	T/A	bu/A	T/A
Check (no companion crop or herbicide)	4.4	0	0
Herbicide (Pre-plant Eptam)	4.8	0	0
Oat forage (Kota oats harvested as forage)	5.9	0	0
Oat grain (Kota oats harvested as grain)	2.0	60	2.0

* The check, herbicide, and oat forage treatments were harvested three times, and the oat grain treatment was cut twice, once for grain and once for regrowth alfalfa forage. Average of three varieties (T3X-8 hybrid, Saranac and Vernal).

Satisfactory **equipment** for seeding varies considerably. The ideal piece of equipment has features which insure that (1) the correct amount of seed is planted, (2) seed is placed at the best depth, and (3) the seedbed is firmly packed.

Seeding equipment includes cultipackers, grassland drills, press drills, grain drills or broadcast seeders; no one seeder works best under all conditions.

Cultipacker seeders are excellent, except on sands where seed may be placed too shallow or on clays with damp surfaces. Seed tubes on grain drills having legume boxes and press wheels are also satisfactory when depth can be controlled. A detailed discussion of seeding equipment is given in FS 503, Planting tame pastures and haylands.

Depth of seeding is more critical with small seed than with large. The small size of alfalfa seed may prevent emergence if the seed is below the surface by as much as ¾ inch. In fine textured soils, ⅓-½ inch is ideal; in light soil, ½-¾ inch is best. Surface planting on a firm bed can work well if there is sufficient rain followed by ideal growing conditions.

Fertilization at seeding time is recommended only when (1) soil tests show extremely low levels of nitrogen or phosphorus, and (2) it is possible to side band or bottom band about 2 inches from the seed, or (3) fertilizer can be applied prior to planting and worked in. This would be especially necessary for phosphorus. Nitrogen can be broadcast on the surface.

Some tests have shown drastic stand reductions when fertilizer has been placed in the furrow with the seed. Recent research on the Belle Fourche Irrigation District in Butte County has shown that phosphate or nitrogen, when concentrated in the furrow and placed in contact with the seed, was of questionable benefit. Large amounts of either nutrient often reduce stands quite drastically.

If potassium is used, even though it is rarely needed in South Dakota, it should be side banded rather than banded below the seed. If a companion crop is used, more than 15 lb/A nitrogen may stimulate the companion crop at the expense of the alfalfa.

Inoculating alfalfa seed with the appropriate bacterium is necessary for alfalfa to produce its own nitrogen.

Inoculation should be done even if buying pre-inoculated seed. Research at SDSU has shown that inoculum already on the seed is often not effective because storage conditions (which can exceed 60° F) can destroy the bacteria. See FS 601, Pre-inoculation and field inoculation.

Fresh inoculum is readily available and costs about $1/bu.

At planting time, seed can be moistened slightly so that the inoculum will stick better, or it can be put on dry and mixed in the drill box. The dry method would require 1½ times the recommended rate.

Inoculation may not always be necessary for the stand to live, but it can be beneficial in several ways: (1) increased yields, (2) higher protein, (3) longer stand life, (4) better growth of the companion grass crop, (5) increased soil nitrogen, and (6) elimination of nitrogen fertilizer applications.

Lime coatings for alfalfa seed have recently gained attention. Coated seed is surrounded by lime based material, and sometimes contains Rhizobia for nodulation and nitrogen production. Minnesota research by the USDA at seven sites on non-acid soils showed no advantage for establishment, nodulation (an index for nitrogen production potential), or for hay yields. At this time, seed coating

The seedbed must receive careful attention. Floating, packing, and seeding is being done here in the spring. A firm seedbed allows this pony press with legume box to place seed at the correct depth.

A cultipacker seeder is commonly used to seed alfalfa. Although some seed is placed at improper depths, satisfactory seeding can be done. The twin row of cultipackers helps to give a firm seedbed.

of alfalfa seed is not recommended.

Seeding rate information from South Dakota trials support earlier recommendations for planting 8 lb of pure live seed (PLS)* an acre. A farmer planning to harvest two or more crops of forage the seedling year should use about 12 lb/A.

The primary difference in yield among seeding rates is in the seedling year (Table 6). In this trial a grain drill with double-disc openers, depth bands, and packer wheels was used. Satisfactory stands were obtained at all rates. By the second year there was virtually no difference among the seeding rates although more weeds were present at the 4-lb rate.

If equipment, seedbed, and growing conditions are ideal, the 4-lb rate can be adequate (although not recommended) and offers considerable savings. On the other hand, if planting and growing conditions are marginal, 16-20 lb/A may not be enough.

The importance of proper seeding equipment was illustrated in a trial which required vastly different quantities of PLS to obtain the same stand (Table 7).

New seeding management with irrigation is relatively simple. Moisture levels should be kept adequate at all times to enable rapid root and top growth.

If weeds are a problem, mow the field as close as practical. Remove residue from the field as soon as it is dry enough to manage as hay. Windrows left for much longer than 5 days may severely damage young stands.

If a companion crop of grain is taken, maintain adequate soil moisture to prevent drought stress of the alfalfa seedlings. If straw residue is left, it should be spread as uniformly as practical to avoid "smothering."

If phosphorus and/or potash are to be used on the established stand, they can be applied after removal of the first crop or the companion crop.

*PLS = purity x germination

Table 6. Alfalfa seeding rate trial with irrigation at Brookings.*

Seeding rate, PLS	Seeding year (1971)	Second (1972)	Third (1973)	Fourth (1974)	Total (1972-74)
lb/A	T/A				
4	3.7	6.3	7.9	7.0	21.2
8	4.3	6.5	8.1	7.5	22.1
12	4.5	6.5	8.2	7.6	22.3
16	4.6	6.4	8.3	7.7	22.4
	alfalfa plants/square foot**				
4	14	13	7	6	
8	26	24	11	10	
12	38	34	16	11	
16	49	40	26	11	

*Average of three varieties (T3X-8 hybrid, Saranac, and Vernal).
**Plant counts were made in June 1971 (6 weeks after planting), and in October 1972, 1973, and 1974.

Table 7. Seeding equipment trial at Brookings with quantities of PLS required to obtain equivalent stands. All were seeded with small grain companion crop.

Seeder	Pure live seed for same stand (lb/A)
Cultipacker	8.0
Grassland drill with depth bands and packer wheels	8.9
Grain drill with small seed box and front mounted, free hanging spouts	10.7
Grain drill with small seed box rear mounted, free hanging spouts	11.4
Grain drill with alfalfa seed mixed with grain	13.3
Broadcast	16.0 +

Water Management

Yields of alfalfa hay are about in proportion to available water supply when the nutrient supply is adequate.

In South Dakota, alfalfa requires about 4.5 to 6 inches of water for every ton of hay. If we assume the water is applied by irrigation systems which are 80% efficient, we would have to apply 5.6 to 7.5 inches of irrigation water for each ton.

Irrigation scheduling is an integral part of alfalfa management. The rate of water use is low immediately after harvest, increases sharply, and reaches a peak at the pre-bud stage. Water required per ton of hay peaks in July and August.

These patterns of water use are quite predictable with variations due largely to weather and harvest schedules. Figure 1 shows an alfalfa water consumption curve for four cuttings; a three cutting curve would have the same type of pattern.

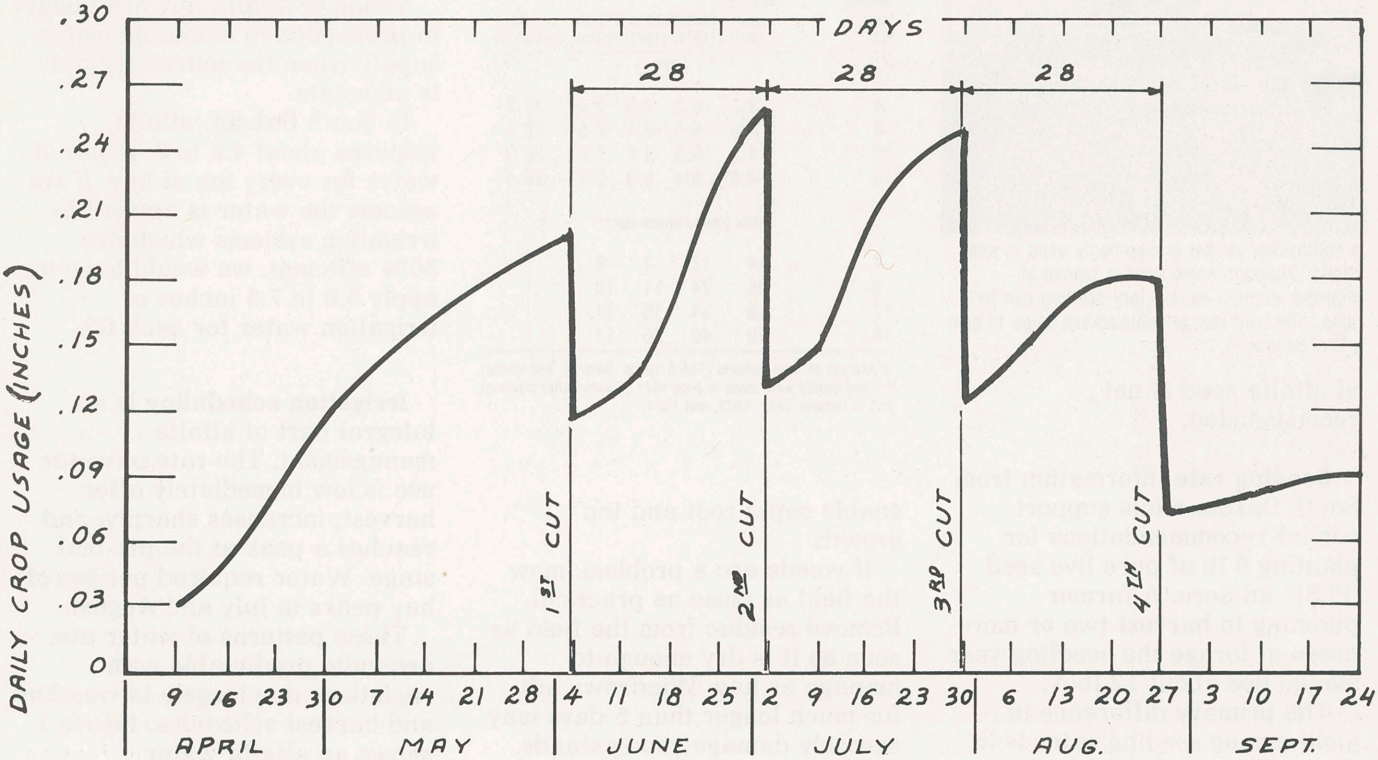
If we assume a normal soil and a normal growing season, the following example illustrates the critical nature of intensive irrigated alfalfa management. As shown by Table 8, if cuttings are delayed by a few days throughout the season, the last cutting (whether there are three, four, or five planned) may not be possible.

It is especially difficult in most of South Dakota to obtain four cuttings during the growing season and still maintain a productive, healthy stand.

When center pivots are used, irrigation scheduling is more critical than with flood systems. Pivots require a greater amount of time for application of water, thereby reducing flexibility.

A 130-acre center pivot operating at 800 gallons per minute with 80% efficiency will apply 0.26 inches per acre daily (Table 9). A cutting of alfalfa may consume 6 to 15 inches of water, depending on

Fig 1. Seasonal water consumption for alfalfa grown in South Dakota, four cuttings.*



*After Del Brosz, SDSU Water Resources Institute

temperature, stand, maturity, etc. Assuming the crop will demand 6 inches of water in 28 days, the 800-gal system at 80% would need to operate for 23 days to meet crop needs. In this case, carryover subsoil moisture is imperative.

The most critical irrigation is the late summer or autumn irrigation. Good levels of soil moisture at this time (1) permit foliage regrowth and root carbohydrate accumulation for good overwintering, (2) lessen rapid temperature changes which damage roots, (3) prevent crown and root drying, and (4) provide stored moisture for the next growing season.

Fall or spring applications of water insure good first cutting production. Spring applications should be delayed sufficiently so that growth is not depressed by wet, cold soil.

Table 8. Example of intensive irrigated alfalfa management scheduling and water budgeting.

Date	Event	Projected yield	Water budget		
			Amount consumed	Source	
		T/A	inches		inches
Before June 1	Fertilize			Stored available	5
	Irrigate			Rain	12
				Irrigate	4
May 25-June 1	1st cutting	2.50	15	Carryover	(6)
	5-10 days to cure			Rain	4
	17 days to irrigate			Irrigate	2
	7 days to dry soil			Irrigate	4
July 6	2nd cutting	2.00	12	Carryover	(4)
	5 days to cure			Rain	1
	21 days to irrigate			Irrigate	4
	6 days to dry soil			Irrigate	4
August 7	3rd cutting	1.50	9	Carryover	(4)
	5 days to cure			Rain	2
	20 days to irrigate			Irrigate	3
	6 days to dry soil			Irrigate	4
Sept. 8	4th cutting	1.25	8	Carryover	(5)
Oct. 8	30 days fall regrowth	Possible grazing	3	Irrigate	3
Total		7.25	47	Stored	5
				(19 rain + 28 irrigation)	

Early spring growth on an experimental alfalfa field shows the effectiveness (left) of autumn irrigation in initiating growth. The right side received no autumn water. The soils are clay and slopes are steep, greater than 5%.

Recent research in Butte County has demonstrated a 0.9 T/A increase in yield on clay soils from a late May irrigation during a dry spring. By contrast, an additional fall plus spring application on a sandy loam soil resulted in a 2-year average increase of only 0.5 T/A.

For maximum production, it often is necessary to irrigate more than once between each cutting. However, restricted applications between cuttings generally will result in satisfactory yields, especially on deep soils with stored moisture.

Over irrigation can be costly and damaging. As long as a deep soil has about 25 to 35% of the available water remaining, additional irrigations may be of little benefit. On soils with low water holding capacity, available water should be nearer 50%.

Ponding or raised water tables can occur after excess irrigation. Damage to roots can result from disease or simply a lack of air. This can produce reduced growth rate or stand loss. Damaging salt accumulations also frequently occur with over irrigation, leaky ditches, or poor soil or water quality.

To guard against over or under irrigation, it is desirable to keep track of total water applied (irrigation plus precipitation) and alfalfa water use rates. This type of moisture accounting can be conducted on a field-by-field basis using generalized alfalfa water use rates (Fig 1). An alternative is to use moisture measuring devices placed at 1-ft and 3-ft depths in representative field locations. One such common device is the tensiometer discussed in FS 602, For timely irrigation: tensiometers.

Table 9. Center pivot capacity and efficiency impact on irrigation time requirements.

	130-acre Pivot system			
Flow capacity of system (gal/minute)	Inches of water/A/day		Days required to apply 20 inches/A	
	70% efficient	80% efficient	70% efficient	80% efficient
500	.14	.16	140	123
600	.17	.20	117	102
700	.20	.23	100	88
800	.23	.26	88	77
900	.26	.29	78	68

Fertility

Proper water management alone may not sustain high economic levels of alfalfa production.

The advantage of combining good water and fertility management has been demonstrated in recent Butte County trials (Figure 2). With "normal" water management the yearly yield increase from the addition of 60 lb/A P_2O_5 was 0.7 T (4.1 vs 4.8); when both additional water and fertility (90 lb of P_2O_5) were applied, the increase over the least intensive management was 1.4 T (4.1 vs. 5.4). Additional water without fertilizer did not significantly increase production.

Alfalfa uses large amounts of plant food elements in its growth when it is compared with other commonly grown irrigated crops (Table 10).

Although **nitrogen** requirements of alfalfa are extremely high, nitrogen fertilizer seldom increases yields because inoculated alfalfa has the ability to utilize atmospheric nitrogen.

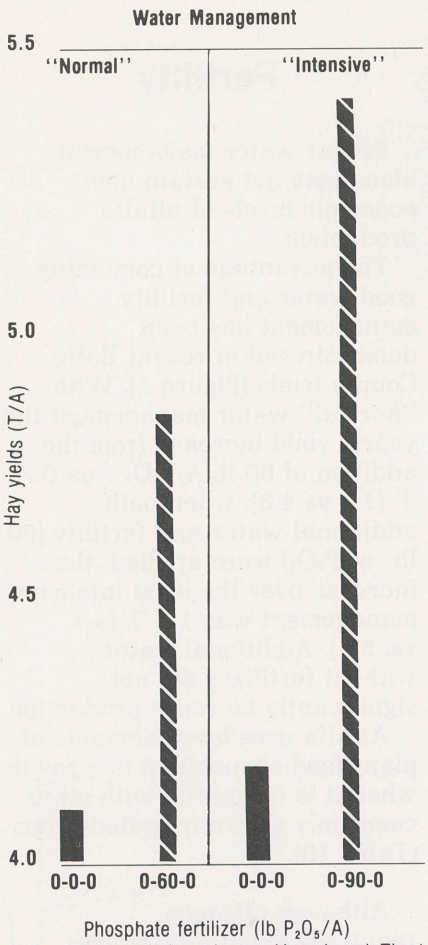
Recent western South Dakota trials showed 60 lb nitrogen per year did not increase yields and tended to suppress yields over a 3-year period. This is consistent with other research in the state.

A small amount of nitrogen (10-15 lb/A) as a starter fertilizer, however, has been shown to aid in stand establishment.

Phosphate fertilizer greatly increases alfalfa yields on many South Dakota soils.

In general, if a soil test is "low," a profitable yield response can be expected. Yield increases from phosphate fertilizer do not always occur

Fig 2. Response of three alfalfa varieties to differences in water management and fertilizer on clay soil, Butte County, 1976-78.

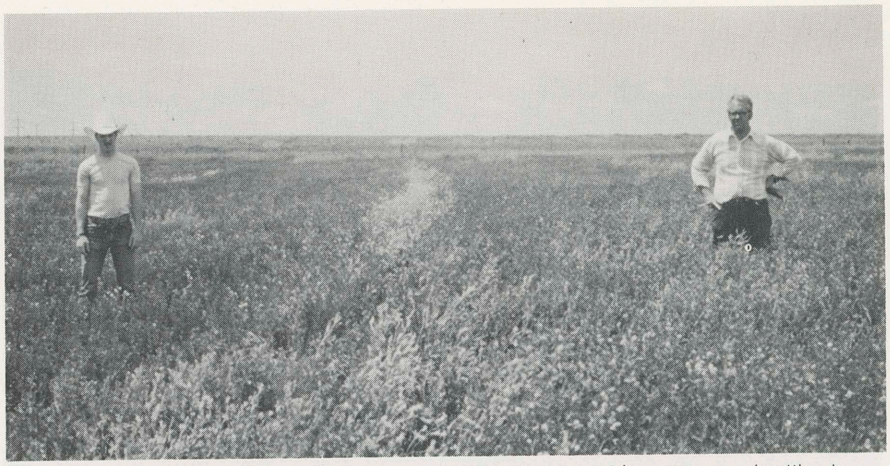


Note: Three varieties (Agate, Vernal and Thor) were in the trial with no production difference among varieties.

when the phosphorus soil test is in the "medium" and "high" range.

We are unable to accurately predict expected fertilizer response at the higher soil test levels for many reasons. Two of the more important are weather and the phosphate holding-yielding capacity of soil.

Even though phosphate tests are not always as accurate as desired, they provide the best method of evaluation available today. Soil tests and check strips (areas without fertilizer) in the field can provide a good understanding of phosphate needs and requirements on each alfalfa field.



Adding water without having the fertility up does not appear to significantly increase alfalfa production. Combined, fertility and intensive water management increase second cutting by more than 0.5 T/A on the right side, as compared to the left.

Available **potassium** levels in most South Dakota soils are high. This means that additions of potash fertilizer will seldom profitably increase yields.

A limited number of soils, primarily in the eastern part of the state, are deficient in potassium. Soils having lower potassium supplying abilities are for the most part lighter textured (sandy) or poorly developed. (However, most sandy soils have adequate available potassium.)

Soil tests are an excellent guide for potash fertilizer recommendations. Small fertilized strips can be a reliable field test for potassium needs.

Table 10. Approximate amounts of plant nutrients removed by crops.

	N	P_2O_5	K_2O
		lb/A	
Alfalfa (hay)*			
(7 T)	385	84	392
(5 T)	275	60	280
(1 T)	55	12	56
Corn (grain + stover)			
(130 bu for 20 T silage)	200	65	170
(100 bu for 14 T silage)	140	50	130
(1 T silage)	10	3.2	9.3
Soybeans (grain)*			
(40 bu)	128	14	48
(1 bu)	3.2	0.3	1.2

*Both alfalfa and soybeans are legumes which have the capability of using atmospheric nitrogen.

Secondary or **micronutrient** levels in most South Dakota soils are high.

However, with long-term intensive agriculture on irrigated soils, deficiencies may occur or may now exist in small areas. Deficiencies in other regions have been seen for sulfur, boron, copper, manganese, zinc, and iron, but production responses have not occurred in South Dakota.

The best prescription for fertilizing alfalfa is to soil test and follow the recommendation for fertilizer amendments from the laboratory which made the test.

Do not have a soil test analysis made at one lab and follow the recommendation for fertilizer from another lab. Because of differences in laboratory procedure or reporting approaches, **laboratory test results cannot be interchanged** with recommendations from other labs.

Whenever a laboratory makes a recommendation for nitrogen or micronutrients, a soil test analysis from another lab should be sought. In the case of phosphorus and potash, local field experience may be necessary to insure profitable responses.

For additional information on fertilizing see FS 425, Fertilizing pasture and hayland.

Cutting Schedules

An alfalfa harvesting schedule is a compromise based on weather, plant vigor, water availability, insect infestations, quantity versus quality, stand longevity, and calendar date. Some discussion is given in FS 528 (rev), Alfalfa management on dryland.

Root carbohydrates or reserves determine the ideal cutting schedule. Carbohydrates provide the energy needed to over winter and initiate growth in the spring and after each harvest. In perennial plants, root carbohydrates are stored during certain periods of above ground plant growth.

With alfalfa, plant height has to reach about 6-10 inches before carbohydrate use stops and accumulation begins. If stands are harvested substantially before the flowering stages indicated in Fig 3, root reserves can be expected to decrease, accompanied by regrowth delays, reduced production, and thinned or killed stands.

Delayed harvests do build up additional stored carbohydrates but do not increase production, as growth rates decrease rapidly after flowering. Furthermore, with delayed harvests, the amounts of digestible protein and energy decrease and the relative amount of fiber increases.

The timing of **first harvest** is critical. Delays can reduce the total number of harvests taken during the year. Take the first cutting as soon as it is ready, weather permitting. This is normally at the late bud to first flower stage. It is equally important to remove the first harvest as soon as possible to allow for irrigation and regrowth. Cutting for greenchop or haylage in wet springs can be good insurance against delayed schedules.

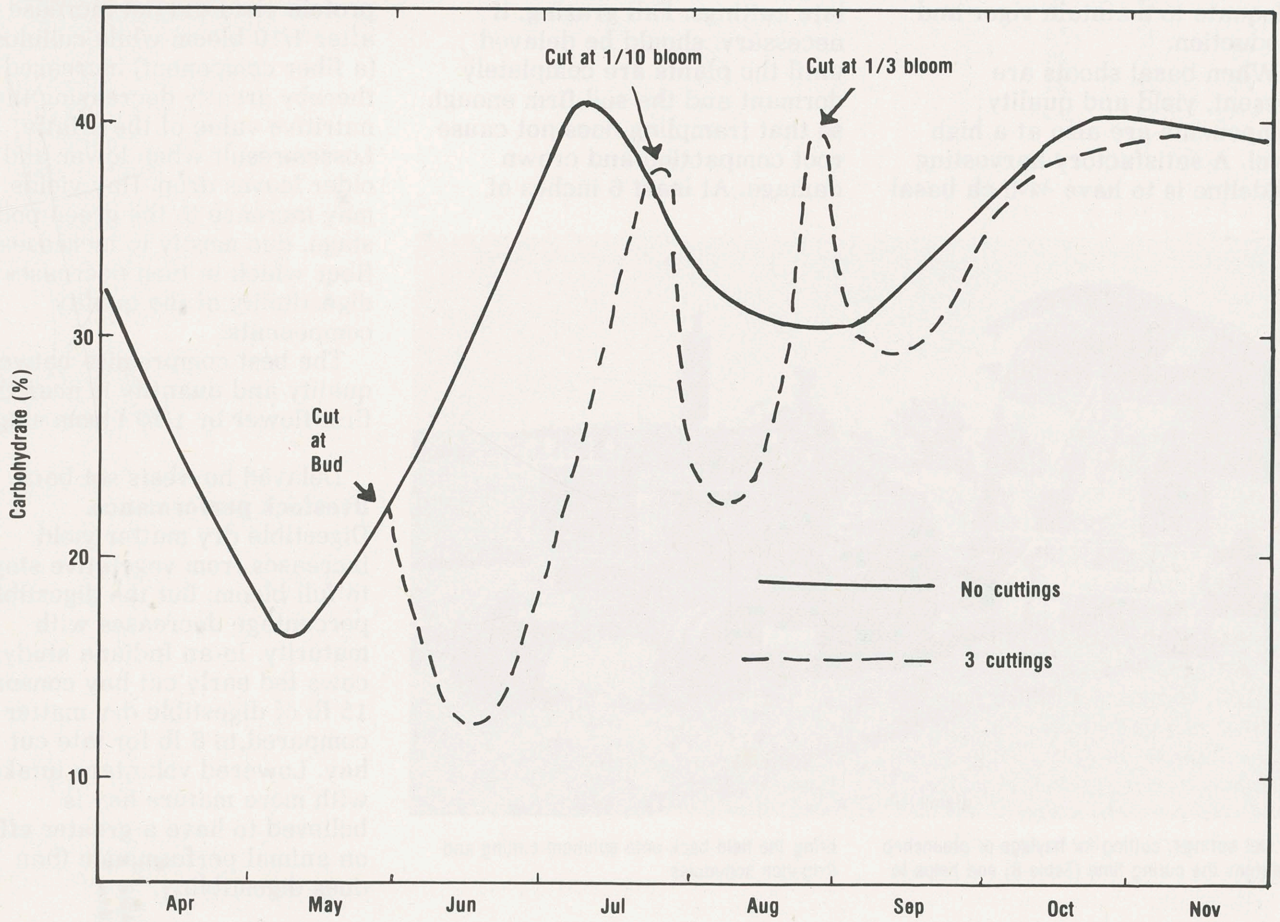
Circumstances that can affect spring schedules are

Condition	**Time the harvest:**
Normal spring	Late bud to first flower
Killing frost	Immediately
Heavy insect infestation	Early
Drought	Early
Winter injured stand	Delay

Killing frosts in the spring can prevent further growth of alfalfa plants and cause leaf drop. Immediate harvesting can salvage some to nearly all of the first cutting; however, removing the top growth may not hasten regrowth.

Fields with **heavy insect infestations** may require insecticide. With alfalfa weevils, early harvest can minimize insect damage, eliminate the

Fig 3. Seasonal trends of alfalfa root carbohydrates. (After Dale Smith in "Alfalfa Science and Technology," American Society of Agronomy No. 15).



need for spraying, and often prevent severe reinfestations later in the season.

Spring drought conditions periodically occur even with irrigation. By the time drought is evident (blue-green color of foliage), additional growth may only be possible from new shoots. For this reason, it is generally best to harvest drought stricken fields early and irrigate as soon as possible for the second cutting.

Winter injured stands may have root or crown damage, as well as reduced levels of stored carbohydrates. Such stands often are slow to make major growth in the spring. Delayed cutting can result in better stand maintenance and production through healthier roots and improved levels of stored nutrients.

In some cases, especially after first harvest, flowering is erratic. In such cases, development of **basal shoots** indicates when root reserves are adequate to maintain vigor and production.

When basal shoots are present, yield and quality components are also at a high level. A satisfactory harvesting guideline is to have ¾-inch basal shoots on about 60% of the plants. Mow before basal shoots are tall enough to be cut off, or subsequent harvest will be delayed.

In terms of stand maintenance and productivity, fall management is more critical than management at any other time during the growing season.

It is difficult to predict when the first killing frost will prevent further growth. Plants need 6-10 inches of green growth before frost to store adequate carbohydrates for overwintering and vigorous spring growth. It is for this reason that recommendations for dryland alfalfa are to harvest before mid-September. The last cutting date for irrigated alfalfa, however, can come in late September in many years in much of the state without serious consequences. The good winter soil moisture provided by irrigation will protect roots and crowns from winter injury.

Heavy fall grazing of alfalfa stands can be as detrimental as late cuttings. Fall grazing, if necessary, should be delayed until the plants are completely dormant and the soil firm enough so that trampling does not cause root compaction and crown damage. At least 6 inches of stubble should be left to provide snow catch for insulation.

In wet springs, cutting for haylage or greenchop shortens the curing time (Table 8) and helps to bring the field back onto optimum cutting and irrigation schedules.

There is an obvious relationship between the **number of harvests,** alfalfa yields, and quality.

If cuttings are too frequent, root carbohydrates will be depleted, yields will suffer even though more harvests are made, and stands may be thinned.

In a 1974 irrigated trial at Redfield, harvesting at full bloom produced the highest yield (Table 11).

However, full bloom harvests cannot be expected to produce the most digestible protein or total digestible nutrients (TDN). Based on standard values and the Redfield data, crude protein and TDN yields do not increase with delayed harvest dates. The increase in hay yields is due largely to the increase in fiber and cellulose. Actual quality of the hay decreases with maturity even though TDN and protein yields remain rather constant.

In a Wisconsin report (Fig 4) protein yield did not increase after 1/10 bloom while cellulose (a fiber component) increased, thereby greatly decreasing the nutritive value of the alfalfa. Losses result when lower and older leaves drop. Hay yields may increase to the green pod stage, due mostly to increases in fiber which in turn decreases digestibility of the quality components.

The best compromise between quality and quantity is near the first flower or 1/10 bloom stage.

Delayed harvests set back **livestock performance.** Digestible dry matter yield increases from vegetative stages to full bloom, but the digestible percentage decreases with maturity. In an Indiana study, cows fed early cut hay consumed 15 lb of digestible dry matter compared to 8 lb for late cut hay. Lowered voluntary intake with more mature hay is believed to have a greater effect on animal performance than does digestibility.

Table 11. Yields and quality of alfalfa harvested at different stages of maturity at Redfield.

Harvest stage	Cutting dates 1st	2nd	3rd	4th	Yields Hay	CP*	TDN*	CF*
					T/A			
Bud	June 3	Jul 3	Jul 24	Aug 28	5.6	1.1	3.5	1.6
1/10 bloom	June 14	Jul 9	Aug 5	Sept 20	6.2	1.1	3.6	1.9
Full bloom	June 21	Jul 11	Sept 20	—	6.4	1.0	3.6	2.1

*Values are estimates based on National Research Council figures. Headings are crude protein, total digestible nutrients, and crude fiber.

Lambs were fed first cut alfalfa-bromegrass hay in a Wisconsin trial. Alfalfa maturity stages were vegetative, first flower, full bloom, and green seed pod; and the lambs gained less on the more mature hay. From the least to most mature hay, daily lamb gains in pounds were 0.38, 0.21, 0.15, and 0.05.

In other Wisconsin research, harvesting three or four times a season at early bloom was compared to harvesting twice at full bloom. The more frequent harvests increased hay yields by 15-25%, total digestible nutrient yields by 30-40%, and crude protein yields by 45-60%.

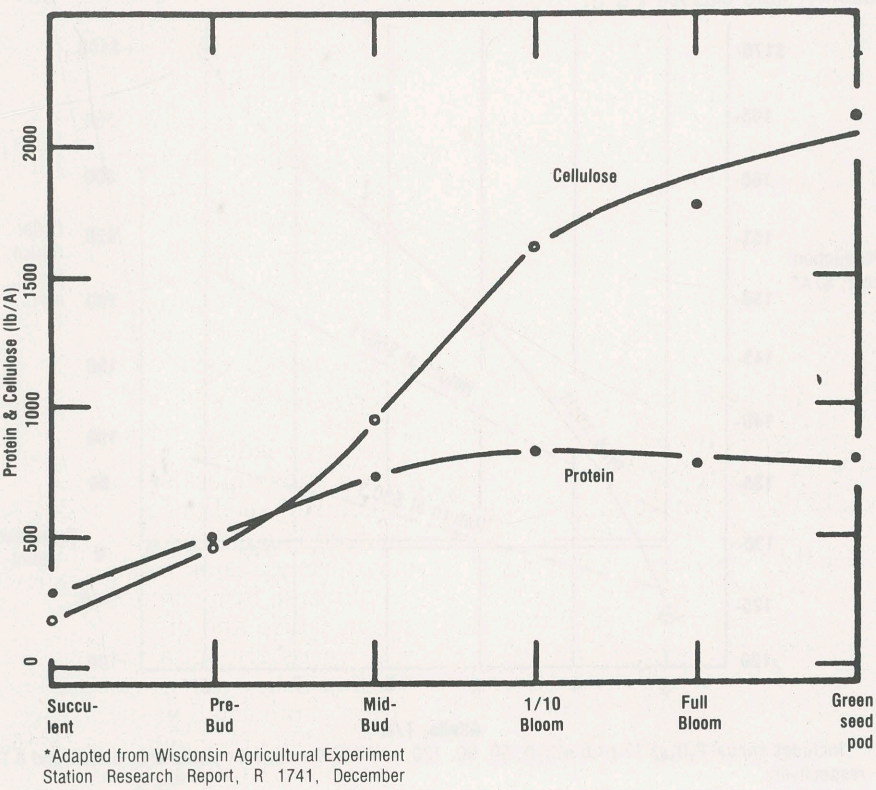
Harvest schedules that are based on plant development rather than calendar date are preferable because of differences between years, locations, and varieties. Calendar date harvest schedules may reduce hay quality and quantity and may damage stands.

First harvest alfalfa loses quality with maturity much more rapidly than do later cuttings. Because of this and because delayed harvests in the spring can result in cancellation of later cuttings, it is important to take the first cutting at an early stage of plant development.

Variations in management that are forced by delays are shown in Table 12. The most common reason for delay is winter injury, in which case delayed cuttings may aid in stand recovery. Later harvests should be based on plant readiness.

As a practical matter, it is important to remember which fields were cut last or most frequently during the year. In the following year, it is best if those fields can be harvested last in spring and/or less frequently.

Fig 4. Yield per acre of protein and fiber for Vernal alfalfa at various stages of growth.*



*Adapted from Wisconsin Agricultural Experiment Station Research Report, R 1741, December 1977.

Harvest Losses

The method of harvest can influence scheduling, yields, and quality. The way the harvested alfalfa will be used obviously dictates the harvest method. There is variation within methods that is important in both yield and quality.

Three harvest methods were compared in eastern South Dakota (Table 13). Green chop alfalfa was considered to have no loss (100% yield). Haylage and baled hay produced satisfactory results in most cases, but weather caused considerable variation for the baled hay. In one case, two rain showers required two hay rakings, reducing yields to 54%. When baled during a dry afternoon, hay yield was 77%, compared to 90% when baled in the evening.

Leaf losses were primarily responsible for decreases, occurring principally when tissue levels were below 20% moisture.

Profitability

Alfalfa is one of the best adapted feed crops for irrigated land in South Dakota. It can be highly profitable, depending on the management and financial

Table 12. Common optimum harvest schedule alternatives as influenced by weather variations.

South Dakota region	Condition	Harvests First	Second	Third	Fourth
Northern	Normal spring, no winter injury	Bud*	Late bloom**	By Sept. 1	——
Southern	Normal spring, no winter injury	Bud*	Early bloom	Full bloom**	By Sept. 20
Northern	Normal spring, winter injury evident	Full***	Full*	By Sept. 1****	——
Southern	Normal spring, winter injury evident	Full***	Mid to*** full bloom	Early bloom	By Sept. 20**** or late fall graze

* In healthy stands, early, high quality harvests set the stage for full production and good stand maintenance.
** In healthy stands, full or late bloom harvest in the next-to-last cutting will help insure high levels of carbohydrates at the critical last harvest.
*** Delayed harvests will help recovery of wintered injured stands.
**** Final harvests may be less productive than normal, or they might be eliminated entirely.

Table 13. Yield and quality as influenced by harvest methods in an eastern South Dakota trial.*

Harvest method	Yield	Leaves	Crude Protein
		%	
Green-chop	100	58	20
Haylage	95	55-57	19
Baled (small)	54-90	44	18

*From research by the SDSU Dairy Science Department.

commitments of operators.

Data in Figure 5 were derived from a research project on Class I and II land in Butte County. In calculating costs and returns, consideration was given to variable field costs and fixed production costs. Costs for management and interest on investment have been included.

In going from 5 to 7 T/A (the normal range of production) costs increase primarily due to increased fertilizer and labor.* As long as returns from increased yields exceed additional production costs, more intensive management will give a greater return. At 5 T/A, $30 alfalfa would barely break even; at 7 T, nearly $50/acre is returned above expenses.

Another index of profitability is a comparison of other crops at comparable yield levels. In Butte County trials with a given yield and 1977 cost structure, alfalfa can be competitive with corn (Table 14). Comparative production costs between alfalfa and corn would not be expected to get narrower—if anything, corn production costs will become relatively higher as nitrogen costs increase. This being the case, the only thing that would prevent alfalfa from being competitive with corn would be a failing price for alfalfa while corn prices hold, or a relatively high price of corn.

For additional information on comparative alfalfa and corn production economics see EC 722, Alfalfa: an economic alternative to corn? and FS 755, Irrigated crop production costs: Big Sioux and Vermillion river basins.

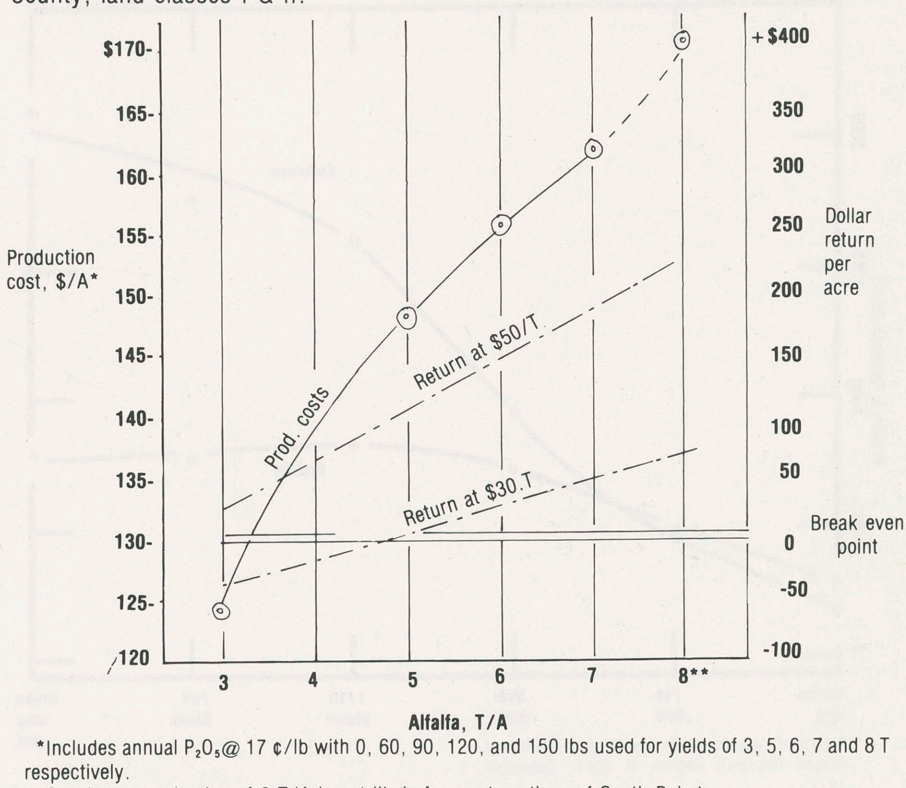
*Water costs were held constant, because water charges in Butte County are based on land capability rather than amount of water used.

Other Publications

For additional information on alfalfa management, consult the following South Dakota Cooperative Extension Service publications:

EC 733, Alfalfa seed production
EC 772, Alfalfa; an economic alternative to corn?
FS 276, Alfalfa weevil
FS 302, Grazing management based on how grasses grow
FS 422 (rev), Interseeding and modified renovation
FS 425 (rev), Fertilizing pasture and hayland
FS 426, Chemical weed control in pasture, range and hayland
FS 503 (rev), Planting tame pastures and hayland
FS 528 (rev), Alfalfa management on dryland
FS 529 (rev), Alfalfa varieties for South Dakota
FS 601, Pre-inoculation and field inoculation
FS 602, For timely irrigation: tensiometers
FS 755, Irrigated crop production costs: Big Sioux and Vermillion river basins

Fig 5. Estimated costs and returns from irrigated alfalfa trials (1974-77) Butte County, land classes I & II.



*Includes annual P_2O_5@ 17 ¢/lb with 0, 60, 90, 120, and 150 lbs used for yields of 3, 5, 6, 7 and 8 T respectively.
**Consistent production of 8 T/A is not likely for most sections of South Dakota.

Table 14. Estimated returns per acre over production costs for Class I and II irrigated land in Butte County.*

	Total production cost	Return after cost	Total production cost	Return after cost
	Alfalfa hay			
Price/T	5T		7T	
$65	$147	$178	$163	$292
55	147	128	163	222
45	147	78	163	152
35	147	28	163	82
	Shelled corn			
Price/bu	100 bu		130 bu	
$2.80	$160	$120	$174	$190
2.50	160	90	174	151
2.10	160	50	174	99
1.80	160	20	174	60

*5T alfalfa vs 100 bu corn and 7 T vs 130 bu require similar management intensities. Primary production cost variables are fertilizer and labor. Assumed 90 lb/A and 120 lb of P_2O_5 for 5T and 7T alfalfa respectively. Assumed 125-60-0 lb/A and 175-80-0 for 100 bu corn yields. Nitrogen calculated at 20¢/lb and P_2O_5@ 17¢.

B 544 (rev), Alfalfa leafcutting bee

PS 47, Alfalfa performance trials 1972-78 (or most recent Plant Science report)

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