Alfalfa Management in North Dakota

R-571 (Revised), November, 1994.

Dwain Meyer, Professor of Agronomy Agriculture Experiment Station
James Helm, Extension Agronomist

Alfalfa is the most widely grown perennial legume in North Dakota. Its primary use is for hay, but it is also used for pasture and haylage and as a green manure crop. The acreage harvested for hay (Table 1) held relatively constant from the mid 1950s to 1970. The acreage increased to nearly 2 million acres during the 1970s and is currently at about 1.7 million acres. During this same time period the acreage of native hay harvested has also decreased. Total hay acreage is influenced most by moisture, increasing during and after dry years and declining after wet years.

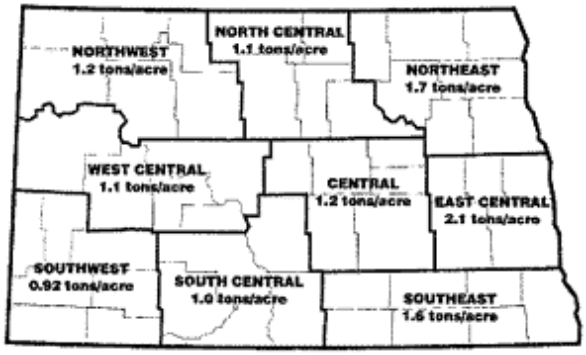
Table 1. Acreage of alfalfa, tame grass and native hay harvested.

Year	Alfalfa	Tame grass & native hay	Total
1960	1,261	2,626	3,887
1965	1,326	2,297	3,623
1970	1,500	2,056	3,556
1975	1,920	1,620	3,540
1980	1,200	1,300	2,500
1985	1,500	1,450	2,950
1990	1,400	2,100	3,500
1992	1,300	1,600	2,900
1993	1,700	1,250	2,950

The North Dakota Agricultural Statistics Service indicates that the average statewide alfalfa yield for the years 1988-1992 was about 1.8 tons/acre. The highest yields (Figure 1) were in eastern North Dakota and ranged from 1.6 to 2.1 tons/acre, compared with yields of 0.9 to 1.2 tons/acre for the remainder of the state. These yields are about 0.5 ton/acre less than the long-term average. In addition, the 25-year average forage yield at Fargo is 4.2 tons/acre, nearly 2.0 tons/acre more than the Cass County average. Several factors contributed to this disparity and indicate the potential for

top-notch producers.

Figure 1. Average yields of alfalfa for years 1988-92 by North Dakota crop reporting districts.



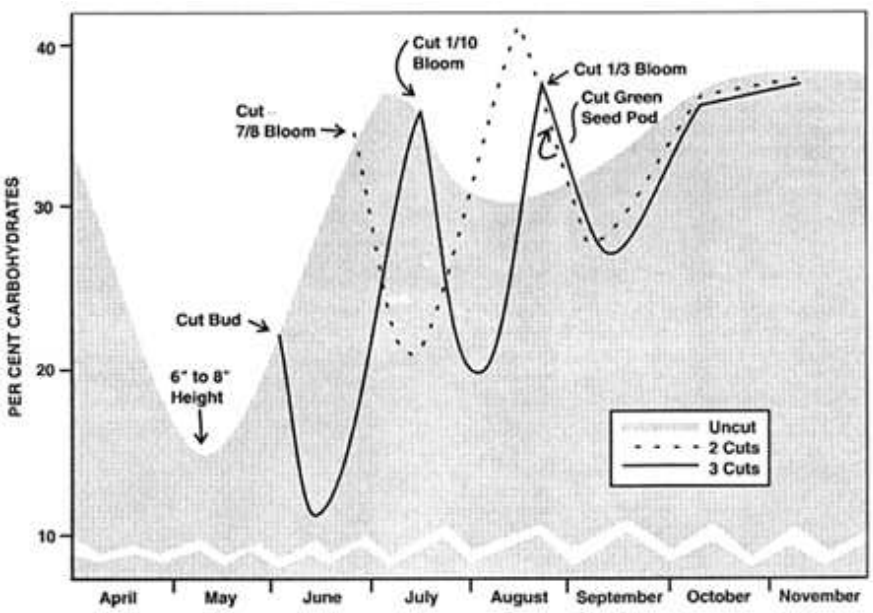
Alfalfa forage yields can be improved or maintained at high levels through the timely application of stand management principles and practices. Consideration should be given to rotation of stands on a regular basis, timeliness and frequency of forage harvesting, packaging and storage, fall management, and soil fertility. Information on individual varieties can be found in NDSU Extension Circular R-681, **"Alfalfa Variety Selection."**

Stand Management

Alfalfa is a perennial crop which must store food reserves or carbohydrates (starches and sugars) in its crown and taproot for winter survival. Adequate food reserves are essential for development of cold resistance, for plant respiration or maintenance during the winter, and to initiate new growth in the spring and following each harvest. A knowledge of the carbohydrate storage pattern in alfalfa is fundamental to understanding the plant's response to various management systems.

Storage of carbohydrates follows a cyclic pattern throughout the growing season (Figure 2). Food reserves decrease in uncut alfalfa until about mid-May, corresponding with about 6 to 8 inches of new growth. As growth continues, the leaves manufacture carbohydrates in excess of normal growth and development needs, allowing storage of "food" in the crown and taproot. Food reserves in uncut alfalfa increase until full bloom in late June or early July, decrease until seed is mature in August, and increase until the first killing frost in the fall.

Figure 2. Seasonal trends of total available carbohydrates in roots of vernal alfalfa with two cuttings, three cuttings and with no cutting.
(adapted from Forage Management in the North, by Dale Smith, 1962.)



Alfalfa cut two or three times annually for hay has a similar cyclic pattern in stored food reserves — decreasing until new growth is 6 to 8 inches tall, then increasing until the next cutting or until the first killing frost (Figure 2). Note that with timely harvesting and/or grazing in the fall, food reserves are maintained at nearly the same level as in uncut alfalfa stands. With an adequate recovery period in early fall, allowing complete recovery of food reserves prior to forage harvest is not necessary. Therefore, maintenance of productive stands is possible even when the forage is removed early (bud to 10 percent bloom) in order to harvest high-quality hay. However, harvest during the fall storage of food reserves may lead to winter injury and reduced life of the stand.

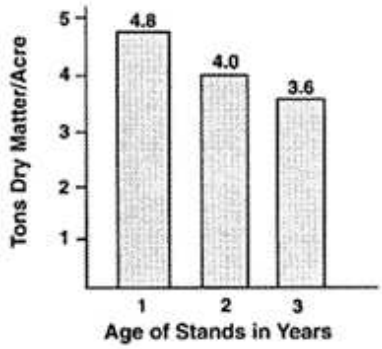
Age of Stand

The productive life of an alfalfa stand is related to the age of stand and the harvest and/or grazing management. Increasing age of stand, too many cuttings during the growing season, untimely fall harvesting, and overuse by grazing animals often result in one or all of the following:

- REDUCED YIELDS
- LIMITED ROOT GROWTH
- INCREASED WINTERKILL AND/OR INJURY
- THINNING OF STANDS
- GRASS AND WEED INVASION
- INCREASED DISEASE SUSCEPTIBILITY

Alfalfa requires approximately 6 inches (plus or minus 1 inch) of water to produce a ton of forage. To produce greater than normal yields for your area, additional moisture must be available through above-normal precipitation or irrigation, or the plant must draw upon stored soil water supplies. A six-year study at Fargo evaluated stand age effects on alfalfa productivity when annual precipitation differences were removed (Figure 3). Forage yields averaged 4.8 tons dry matter/acre during the first harvest year, 4.0 tons/acre in the second year, and 3.6 tons/acre in the third year, a decrease of 1.2 tons/acre between the first and third production years. The value of this loss of production will compensate for the cost of establishing a new stand.

Figure 3. Influence of age of stand on alfalfa forage yields, Fargo, ND.



Forage yields decreased with increasing stand age in all years tested in another experiment at Fargo (Table 2). The greatest decrease occurred in 1980, a very dry year. The three-year-old stand produced 54 percent less forage than the one-year-old stand. But in average to above- average precipitation years like 1981 to 1984, stand age (three to four-year-old stands) had less effect on productivity. Older stands (six to seven-year old) were less productive, averaging nearly 2 tons/acre less. Much of the lower productivity of older dryland stands is because of depletion of deep subsoil moisture, but it may also be due to loss of plant density, accumulating winter injury/winterkill effects, and weed encroachment.

Table 2. Stand age effects on alfalfa forage yield at Fargo*

Stand age	Harvest year 1979	1980	1981	1982	1983	1984
Years	- - - - - - - tons dry matter/acre - - - - - -					
1	5.2a	3.4a	4.9a	4.2a	4.3a	4.9a
2	4.1b	2.6b	4.6a	3.7a	3.9ab	4.6a
3		1.6c	4.5a	3.6ab	3.4b	4.6a
4			3.9a	2.9bc	3.3bc	3.6b
5				2.6c	3.1bc	3.7b
6					2.5c	3.2b
7						2.9b

* Average of three varieties

Irrigated alfalfa yields also decreased with stand age at Carrington (Table 3.) First-year productivity averaged 1.0 ton/acre greater than second-year and 2.1 tons/acre greater than third-year. Note that in 1990 a stand was winterkilled, but the zero yield was not included in the average, and the third-year productivity average is higher because of this deletion. The observed reduction in yield of irrigated alfalfa with stand age is believed to be associated with accumulating winter injury effects.

Table 3. Stand age effects on irrigated alfalfa production.

Year of experiment	Harvest year First	Second	Third
	- - - tons dry matter/acre - -		
1969-71	5.8	4.8	2.8
1973-75	5.0	3.7	3.7
1978-80	6.6	5.3	3.4
1979-81	7.2	5.2	3.7

1984-86	5.3	5.1	4.5
1987-90	5.0	5.4	0.0*
1992-94	4.8	3.4	--
Average	5.7	4.7	3.6

* Winterkilled, deleted from average

Harvest Frequency

The number of cuttings obtained from an alfalfa stand depends on the available soil water for regrowth. In general, one to two cuts are usually obtained in central and western North Dakota and three cuts in the Red River Valley area and under irrigation. The growth stage at which first-harvest forage is removed has a major influence on forage quality. In addition, the later the first crop is removed under dryland conditions the less subsoil water available for regrowth. Only a small increase in forage yield is obtained by delaying harvest past the 10 to 20 percent bloom growth stage, but forage digestibility and forage intake by livestock decreases 0.3 to 0.5 percent per day.

Early alfalfa management studies at the Dickinson Research Extension Center (Table 4) show that an early two-cut system (June 20 and August 10 at 10 to 50 percent bloom) produced the greatest forage yields when compared with the late two-cut or full-bloom systems. Only limited fall regrowth was obtained from the early two-cut system. Forage quality of first-harvest forage is related to the growth stage when harvested, and even though the forage yields between early and late-bloom hays were similar, quality of the forage would dictate early harvest. The early two-cut harvest schedule produced the highest yield of quality forage and should be given consideration in the western one-half to two-thirds of North Dakota where only one to two cuts are usually obtained.

Table 4. Three-year average forage yield by harvest frequency at Dickinson, ND.

Cutting schedule*	Cuts 1 & 2	Fall	Seasonal
	- - - tons dry matter/acre - - -		
Early 2-cut	3.5	---	3.5
Early 2-cut + 9/15	3.6	0.3	3.9
Early 2-cut + 10/1	3.8	0.6	4.3
Early 2-cut + 10/15	3.5	0.3	3.8
Late 2-cut	3.4	---	3.4
Late 2-cut + 10/1	3.4	0.0**	3.4
Full bloom	2.6	0.0	2.6
Full bloom + 10/1	2.4	0.9	3.3

* Early 2-cut = 6/20, 8/10; late 2-cut = 6/30, 8/30; full bloom = 7/11.
** Limited to no regrowth.

The Dickinson experiment (Table 4) was harvested by date, but a wiser management practice is to harvest alfalfa by growth stage. Highest three-year average forage yields averaged over five varieties were obtained at Fargo with three harvests taken at appearance of first flower plus a fall harvest (Table 5). Three cuts on a calendar basis (June 15, July 20, and August 30 at about 10 percent bloom for Vernal) followed closely in yield. But note that the forage yield from the calendar schedule was the lowest in the third-harvest year. Unpublished data at North Dakota research centers (Table 6) also shows the value of early harvest in maintaining alfalfa productivity. Statewide average dryland yields increased with delaying harvest from late bud to the 10 percent bloom growth stage, but then decreased with further delayed harvest, primarily because of leaf loss caused by moisture stress.

Table 5. Three year average alfalfa forage yields harvested by growth stage at Fargo.

Cutting schedule	Harvest	Harvest year First	Second	Third	Average
		- - tons dry matter/acre - - -			
Calendar*	(3)	6.0	4.6	4.1	4.9
First flower (FF)	(3)	5.5	4.4	4.2	4.7
First seed pod (FS)	(3)	4.7	4.1	4.3	4.4
FF plus fall	(4)	6.3	4.3	4.6	5.1
FS plus fall	(4)	5.3	4.5	4.7	4.8

* Harvested June 15, July 20, and August 30.

Table 6. Three-year dryland forage yield of Vernal alfalfa by growth stage.

Location	Growth stage Late bud	10% bud	50-75% bloom	First seed pod
	- - - tons dry matter/acre - - - -			
Dickinson	1.6	2.1	2.2	2.0
Fargo	3.1	3.6	3.3	3.9
Hettinger	2.0	1.9	2.0	1.9
Langdon	3.1	3.8	3.3	2.6
Minot	3.1	3.2	3.3	2.8
Williston	2.3	2.8	2.2	2.1
Average	2.5	2.9	2.7	2.6

Forage Quality

Forage quality of alfalfa decreases as maturity or growth stage increases. Crude protein and digestible dry matter decrease, while acid-detergent fiber (ADF) and neutral-detergent fiber (NDF) increase with advancing growth stage (Table 7). The increased fiber content and decreased digestibility sharply reduces the amount of forage intake, which lowers animal performance. A high-quality alfalfa hay should have a relative feed value (RFV) in excess of 150. Note that 10 percent bloom alfalfa hay had a RFV of 159 and basically a 20-30-40 (%) protein-ADF-NDF relationship. Most first-harvest 10 percent bloom hay, however, will not make RFV = 150 hay. Data in Table 6 used hand-harvested samples with no leaf loss. If a typical 15 percent leaf loss is assumed, the forage quality of the 10 percent bloom hay was reduced to that of the 80 percent bloom hay. This suggests that to obtain the 20-30-40 hay, harvest must occur before 10 percent bloom, at late bud or first flower.

Table 7. Forage quality of alfalfa at three growth stages at Fargo in 1992.

	Growth stage Mid-bud	10% bloom	80% bloom
	- - - - - % - - - - -		

Crude protein	22.2	20.7	18.4
Acid-detergent fiber (ADF)	25.2	30.6	37.4
Neutral-detergent fiber (NDF)	33.3	39.4	48.2
Digestible dry matter (DDM)*	69.2	65.1	59.8
Dry matter intake (DMI)*	3.6	3.0	1.9
Relative feed value (RFV)*	199	159	125

* DDM % = 88.9 - (0.779 + ADF), DMI (% of body weight) equals 120/NDF, RFV = (DDM + DMI)/1.29.

Optimum management of alfalfa hay therefore is a compromise between quantity (yield) and quality. Under ideal conditions, late bud or first flower is the optimum growth stage to harvest alfalfa. But many factors may alter this optimum stage, including wet weather conditions during haying season, class of livestock fed, stored soil water, earliness or lateness of season, wet soils, and winter injury to stand.

Cutting Recommendations

NEW PLANTINGS of alfalfa utilizing clear or no-till seeding techniques should produce one or two harvests during the seeding year, especially in higher rainfall areas, on good moisture sites, or under irrigation. Alfalfa harvested during the establishment year should grow to the 10 to 25 percent bloom growth stage before harvesting the first cutting to enable the young plants to become well established, although earlier harvest has not been detrimental to stands in high-moisture areas. Alfalfa seeded with a companion crop usually does not grow tall enough after removing the companion crop for an economical forage harvest. If sufficient growth is obtained, it usually occurs in September and harvest should be delayed until air temperatures have dropped low enough to restrict regrowth, or until just prior to or immediately after the first killing frost.

ESTABLISHED STANDS should be harvested using a combination of growth stage and calendar date to determine the best harvest date. The first cutting must usually be taken before mid-June to allow time for three cuttings prior to August 20-25 in an average year. The first crop should be harvested by the 10 percent bloom stage (late bud to early bloom), especially in the Red River Valley area or under irrigation where three annual cuttings usually are obtained. Delayed harvest lowers the quality of the first harvest the most. Advantages of an early harvest are that a near maximum yield of quality forage is obtained, root reserves for regrowth have been adequately replenished, and soil water usually remains to initiate new growth. Forage quality of second and third-cut alfalfa is less affected by delayed harvest. Harvesting third cutting at 10 to 50 percent bloom will allow buildup of root reserves to aid in overwintering, and forage will be of high quality. However, remember that the alfalfa plant is ready to be harvested whenever regrowth has initiated at the bottom of the canopy, regardless of the maturity stage. Third-harvest irrigated alfalfa may initiate regrowth prior to initiating bloom due to the environmental conditions. In this case, harvest early enough so that most regrowth shoots are not removed.

Fall-stored soil water and May-June precipitation provide a good indication whether two cuttings are possible on old dryland stands. If adequate moisture is available, cut early to retain as much soil moisture as possible for regrowth. If soil moisture is limited or the alfalfa matures earlier than normal, harvest the crop at early bloom stages for best quality. In addition, the number of cuttings is limited by the percentage of grass in alfalfa-grass mixtures. Grass regrowth following harvest is very limited, so the percentage of alfalfa in alfalfa-grass mixtures usually determines whether a second cutting is economical.

If large acreages of alfalfa must be harvested, begin cutting early at the mid- to late-bud growth stage. This will yield a higher overall quality forage from all fields. Another alternative is to plant a

portion of your acreage to Class 4 varieties. These varieties are usually one to several days earlier maturing than the more dormant types (Classes 2 and 3), permitting earlier harvesting.

Bloom Stages

Harvest recommendations are based on the flowering growth stage of alfalfa - early bud; late bud; and 10, 20, and 30 percent bloom; etc. To determine bloom stage of alfalfa, randomly select 10 stems at several locations in the field. Count the number of stems and determine those which have one or more flowers open. If only one stem out of 10 has one or more flowers open, the crop is at 10 percent bloom. If all flowers are open on every stem, the crop is at full bloom.

Stubble Height

The influence of stubble height and cutting frequency on forage production and quality was studied at Fargo (Table 8). Stubble heights of 1 inch to simulate mower bar harvest and 3 to 5 inches to simulate swather harvest were used. Forage production was slightly higher under the two-cut system; however, the quality of hay as indicated by protein and digestible forage per acre was superior from the three-cut system. Increasing the stubble height increased the percent protein and digestibility of the forage but reduced forage production about 0.5 ton/acre for each 2 inches of stubble left standing in the field. Protein and digestible forage yields per acre of the 3-inch stubble height of the three-cut system, however, were similar to the 1-inch stubble height. This indicates that the swather can be used efficiently to harvest alfalfa if operated to obtain the lowest stubble height possible. However, presence of pocket gopher mounds frequently causes excessive stubble heights and resulting yield losses.

Table 8. Dry matter, protein, and digestible-forage yields of alfalfa by stubble height and harvest frequency at Fargo.*

Stubble height	Dry matter	Protein	Digestible forage
	tons/acre	lb/acre	tons/acre
		2 cuts*	
1 inch	5.0	1750	3.1
3 inch	4.5	1600	2.9
5 inch	4.1	1530	2.7
		3 cuts*	
1 inch	4.9	2000	3.2
3 inch	4.6	1940	3.2
5 inch	3.7	1650	2.5

* Approximate harvest dates: 2-cut = July 1, August 31; 3-cut = June 15, July 25, August 31.

[NEXT]

[Harvest Losses] [Grass-Alfalfa Mixtures] [Fall Harvest Management]
[Winter Injury] [Spring Frosts] [Drought Stress] [Soil Fertility]
[Irrigation Water Management] [Production Economics]

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