Alfalfa Management In North Dakota

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Alfalfa is the most important perennial legume grown for forage and dehydration in North Dakota. Alfalfa provides a low cost, dependable, home-grown source of protein, energy, and some vitamins and minerals for livestock, including the cow-calf (North Dakota's number one livestock enterprise).

Most alfalfa for livestock is preserved as loose or baled hay, using many types of labor-saving machines. The popularity of self-propelled swathers and various flail-type harvesters has increased rapidly in the last several years. Swathing usually decreases the harvesting cost as compared to conventional mowing and raking ($0.60 vs 1.78/ton) (2). Swathing may improve forage quality under good drying conditions by reducing leaf loss which occurs during raking (1). However, swathers frequently leave higher stubble heights as compared to stubbles remaining after conventional mowing, which possibly reduces forage yield. Producers have suggested that higher stubble heights also may result in faster regrowth.

Alfalfa cut at a 5-inch stubble height under a 3-cut system in Nebraska produced a significantly lower forage yield than alfalfa cut at a 2-inch height (8). Alfalfa cut at the 5-inch stubble height produced hay of higher protein percentage than alfalfa cut at the 2-inch height, while total protein production per acre was higher from alfalfa cut at the 2-inch stubble height. Cutting alfalfa at 1- or 3-inch stubble heights under a 3-cut system in Wisconsin during a 2-year period had no effect on protein production per acre (5), but forage yield of plants harvested at the 3-inch stubble height was reduced significantly during the second harvest year. The influence of stubble height under varying harvest frequency has not been studied under field conditions.

Alfalfa yields and stand maintenance are influenced by the number of annual harvests (1, 3, 5). Carter (1) found in eastern North Dakota that nine alfalfa varieties under a 3-cut system harvested at early bloom produced the highest yield of good quality, high protein, leafy alfalfa hay when compared to a 2- or 4-cut system. Recent studies in Minnesota indicated that early harvested (3-cut) hay was higher yielding (4.4 vs 4.2 tons dry matter (DM/acre), higher in per cent crude protein (20.1 vs 15.6%), lower in per cent crude fiber (29.5 vs 35.8%) and higher in per cent **in vitro** dry matter digestibility (64.3 vs 60.1%) than late harvested (2-cut) hay (3). However, alfalfa forage yield may be higher from a 2-cut than 3-cut system following winters when differential winter injury occurs (4).

The influence of stubble height (1, 3 and 5 inches) and harvest frequency (2- and 3-cut systems) on Vernal alfalfa stand maintenance, forage production, forage quality and regrowth rate was examined during 1966-71. Cutting at a 1-inch stubble height was chosen to simulate harvest by conventional mowing, while cutting at 3- and 5-inch stubble heights were chosen to simulate harvest by swathers.

Methods and Materials

Six treatments (1-, 3- and 5-inch stubble heights under 2- and 3-cut systems) in a randomized complete block design with four replications were initiated during 1966 on an excellent, uniform stand of Vernal alfalfa established with a wheat companion crop in 1965. Fertilizer was not applied for the first five years, since previous trials indicated little need for either phosphorus (P) or potassium (K) fertilization on Fargo clay soils (4). Soil samples in 1970 indicated 38, 28 and 420 lbs/acre nitrogen, P and K, respectively. P as superphosphate (0-46-0) and K as potash (0-0-62) were broadcast separately at 21 and 99 lbs/acre, respectively, in 1970 to help ensure adequate soil fertility.

Forage yields for the 2-cut system were taken at or near full bloom maturity, usually the first week in July and the last week in August. Forage yields for the 3-cut system were taken at first flower to 10 per cent bloom except the third harvest in 1967, 1969 and 1971 which was harvested at 25 to 40 per cent bloom. Per cent stand, surface area covered by vegetative tissue and plant vigor were visually estimated each spring and fall; only data where significant changes occurred are reported. Plant vigor was rated between 1 (active, vigorous) and 9 (all plants dead). Forage samples were collected in 1968 through 1971 for chemical determination. Per cent crude protein was determined by the microkjeldahl method. Per cent **in vitro** dry matter digestiblity (% IVDMD) was determined by the Tilley and Terry (7) method with modification for direct acidification following the first 48-hour

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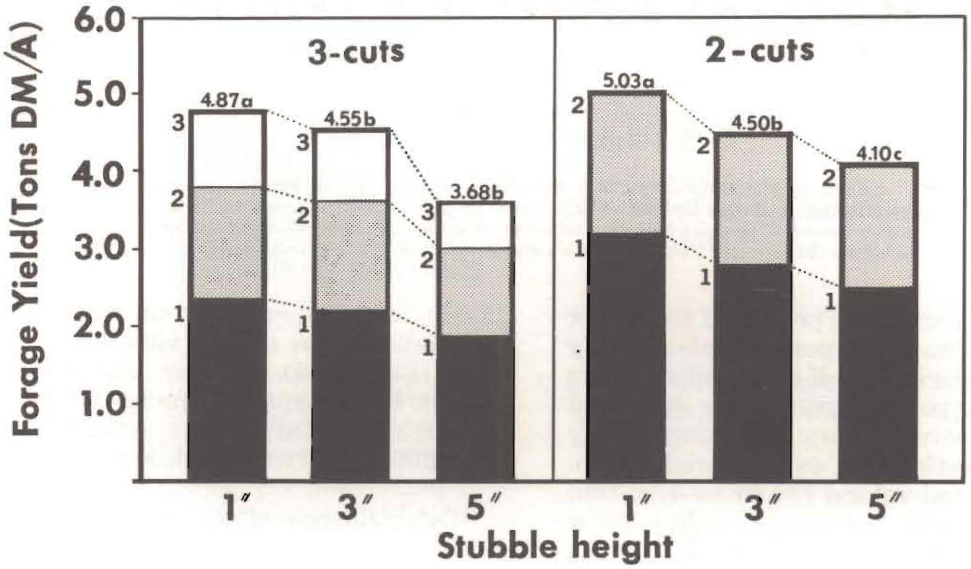

Figure 1. Average annual forage yield of Vernal alfalfa as influenced by stubble height and harvest frequency at Fargo, North Dakota, 1966-71. Forage yield means followed by similar letters are not significantly different at the 5% probability level.

digestion period. Per cent crude protein and per cent IVDMD were estimated for 1966 and 1967 by averaging the 1968-71 data. Per cent new stems originating from crown tissue was estimated following the first and second harvest in 1967 and 1968.

Results

Stand Persistence

Alfalfa stand persistence was influenced by the stubble height and harvest frequency (Table 1). Spring, 1968, alfalfa stand estimates were significantly lower in plots harvested at 1-inch stubble heights than those harvested at 3- and 5-inch stubble heights following mild winter injury during the 1966-67 winter and severe injury during the 1967-68 winter. Spring plant growth in 1968 was more vigorous when cut at 5-inch as compared to 1- and 3-inch stubble heights. Harvest frequency had little effect on spring stand estimates. Better winter survival with higher stubble heights may be associated with a higher level of total available carbohydrates in plant roots prior to fall freezing (5). Differential snow cover related to stubble height was not observed in this experiment, although stubble height generally is recognized as important for trapping snow.

Alfalfa plots harvested twice annually at full bloom were taller, more vigorous and possessed better stands during fall 1968 than plots harvested three times annually at about one-tenth bloom.

Table 1. Per cent stand and plant vigor of Vernal alfalfa as influenced by stubble height and harvest frequency at Fargo, North Dakota.

Frequency and height	Per cent stand				Plant vigor[1]/		
	5-10-68	10-11-68	5-7-70	5-5-71	5-10-68	10-11-68	5-5-71
2-cuts							
1-inch	81 b[2]/	88 b	85 ab	69 c	4.3	4.8	3.0
3-inch	93 a	98 a	91 a	76 ab	3.5	3.2	2.3
5-inch	99 a	100a	89 ab	79 a	1.5	2.2	2.0
Avg.	91	95	88	75	3.1	3.4	2.4
3-cuts							
1-inch	83 b	82 c	83 b	71 bc	5.0	5.5	3.3
3-inch	95 a	91 b	90 a	78 a	4.3	5.2	2.8
5-inch	99 a	99 a	91 a	83 a	1.5	5.0	2.0
Avg.	92	91	88	77	3.6	5.2	2.7
C.V.	5.1	5.0	5.0	5.1			

[1]/Vigor rating: 1-active, vigorous, 9-all plants dead.

[2]/Treatment means within the same column followed by the same letter are not significantly different at the 5% probability level.

Apparently, the 2-cut system allowed an adequate time interval before, or between, harvests in 1968 for injured plants to regain vigor and increase in plant size. By spring 1970 (the fifth harvest year), stands of 2- and 3-cut systems were similar, but harvesting at 3- and 5-inch stubble heights resulted in more vigorous plants and better stands than the 1-inch stubble height throughout the duration of the experiment. These data substantiate Carter's (1) observations that taller stubble heights favored better winter survival and stand maintenance.

Forage Yield

Alfalfa forage production decreased approximately one-half ton dry matter/acre/year for each additional two inches of stubble height above one inch remaining after harvest based on an average of the 2- and 3-cut systems (Figure 1). Stubble height influenced forage yields more during the first and third harvests of the 3-cut system and affected both harvests of the 2-cut system. Forage yields at 1- and 3-inch stubble heights were similar between cutting systems; the forage yield of the 5-inch stubble height was significantly lower under a 3-cut than under a 2-cut system.

Stubble height remaining after harvest greatly affected forage yield during the first harvest year, generally the highest yielding year (Figure 2A). Leaving four additional inches of stubble (1-vs 5-inch) under a 3-cut system during the first harvest year resulted in 2.33 tons DM/acre remaining in the field as stubble. Leaving an additional 4-inch stubble under the 2-cut system during the first harvest year resulted in only 1.22 tons DM/acre remaining in the field as stubble. Forage production following the significant winter injury of 1967-68 was similar across stubble heights due to less injury to plots cut at higher stubble heights. Cutting at a 5-inch stubble height increased the stability of forage production over the six years, but stability was gained with a loss in yield potential.

Alfalfa harvested three times by September 1 produced 0.18 ton DM/acre less total forage/year than alfalfa harvested twice as an average of stubble heights (Figure 1). This is in contrast to Carter (1) who reported higher yield from the 3-cut system with Vernal and eight other varieties during a 1954-58 test period. Differential winter injury among treatments was not experienced during those test years. The mild winter injury experienced during 1966-67 probably reduced plant vigor and stand of the 1-inch, 3-cut treatment only, thereby reducing forage yield as compared to the 1-inch, 2-cut system in 1967 (Figure 2A). Plants subjected to the other treatments were not injured until the 1967-68 winter; therefore, forage production in the 3-inch, 3-cut system approached being significantly higher than the comparable 2-cut system during 1967. All 1969 forage yields were significantly higher than 1968 yields for all treatments indicating that alfalfa has the ability to recover from severe winter injury. Forage yields were lower under the 3- than the 2-cut system for two years following severe winter injury of 1967-68. Apparently, greater stress of a 3-cut system and the shorter time interval between harvests were insufficient for plants to regain the same vigor level as the 2-cut system. Forage yield by the 3-cut system was comparable (1-inch) or greater (3-inch) than the 2-cut system by the third harvest year (1971) after severe winter injury. Forage yields from the 5-inch stubble height treatments were lower in all test years from 3- than 2-cut system.

Forage Quality

Stubble height and harvest frequency influenced the quality of alfalfa forage harvested. Crude protein was 2.3 and 5.3 per cent higher in 3- than 2-cut alfalfa hay in the first and second harvests, respectively (Table 2). Second harvest forage contained the same protein percentage as first harvest forage under the 2-cut system, but second harvest forage contained 3 per cent more protein than first harvest forage under the 3-cut system. Carter (1) reported that the mean protein content of four varieties (1954-58) was 1.4 and 2.4 per cent higher in 3- than 2-cut alfalfa hay in the first and second harvests, respectively. Leaving additional stubble height tended to increase per cent protein in hay under both harvest frequencies in all except the third harvest of the 3-cut system. Harvesting alfalfa at full bloom or later (2-cut system) as compared to harvesting at one-tenth bloom stage (3-cut system), especially during the first harvest, resulted in considerable lower leaf loss due to shading and leaf diseases.

Table 2. Average per cent crude protein in Vernal alfalfa hay as influenced by stubble height and harvest frequency at Fargo, North Dakota, 1968-71.

Harvest frequency	Stubble height	Harvest number[1]/ I	II	III	Total
		—percent crude protein[2]/—			
2-cuts					
	1-inch	17.4	17.2		
	3-inch	17.7	17.7		
	5-inch	18.5	18.7		
	Aug.	17.9	17.9		
3-cuts					
	1-inch	19.1	22.3	21.4	
	3-inch	20.0	23.1	21.4	
	5-inch	21.4	24.2	21.5	
	Aug.	20.2	23.2	21.4	

[1]/Average harvest dates: 3-cut—I=June 18, II=July 20, III=August 28; and 2-cut—I=July 4, II=August 28.

[2]/Per cent crude protein = Kjeldahl N x 6.25.

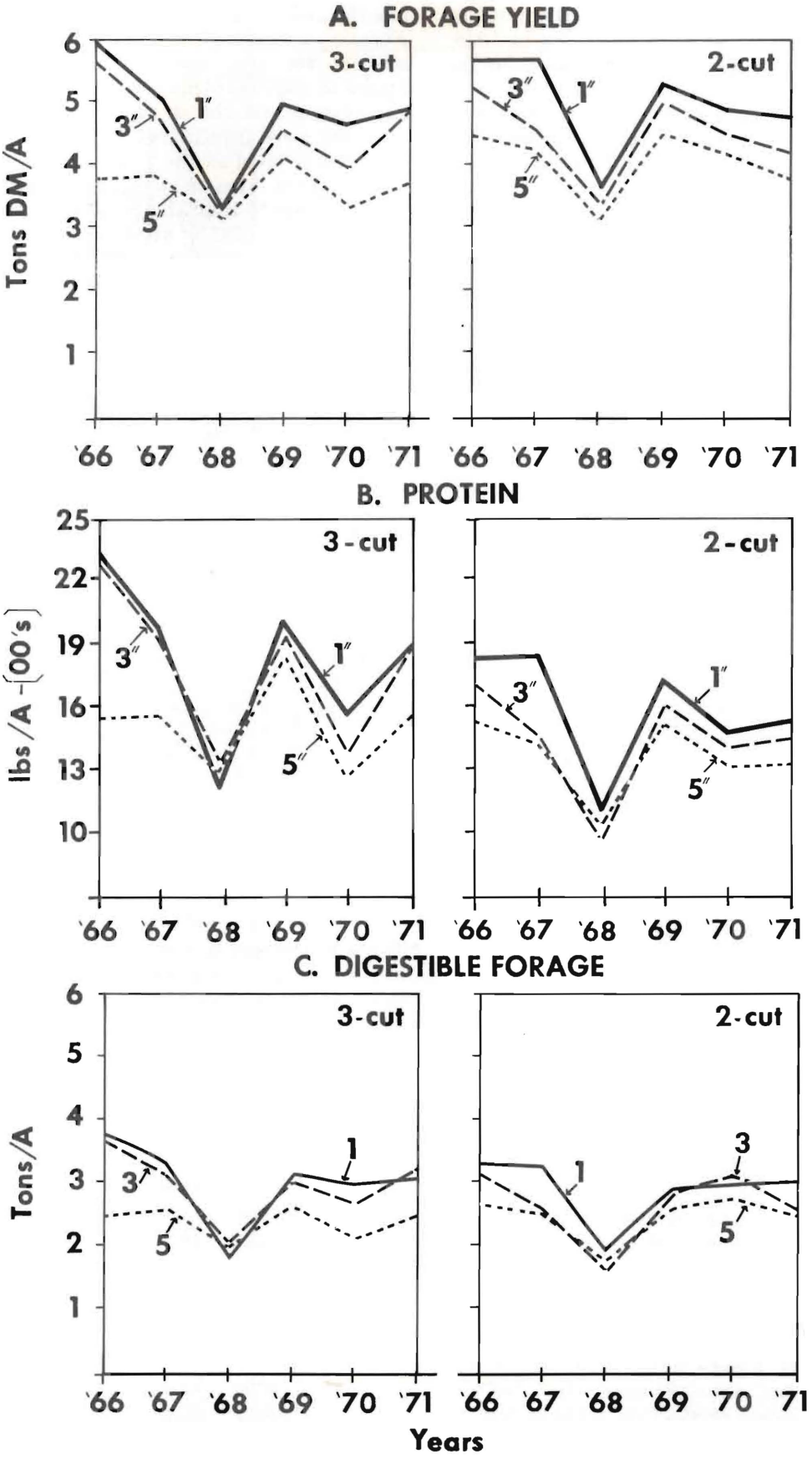

Figure 2. Forage yield (A), pounds crude protein produced per acre (B), and total digestible forage produced per acre (C) by Vernal alfalfa as influenced by stubble height and harvest frequency at Fargo, North Dakota, 1966-71.

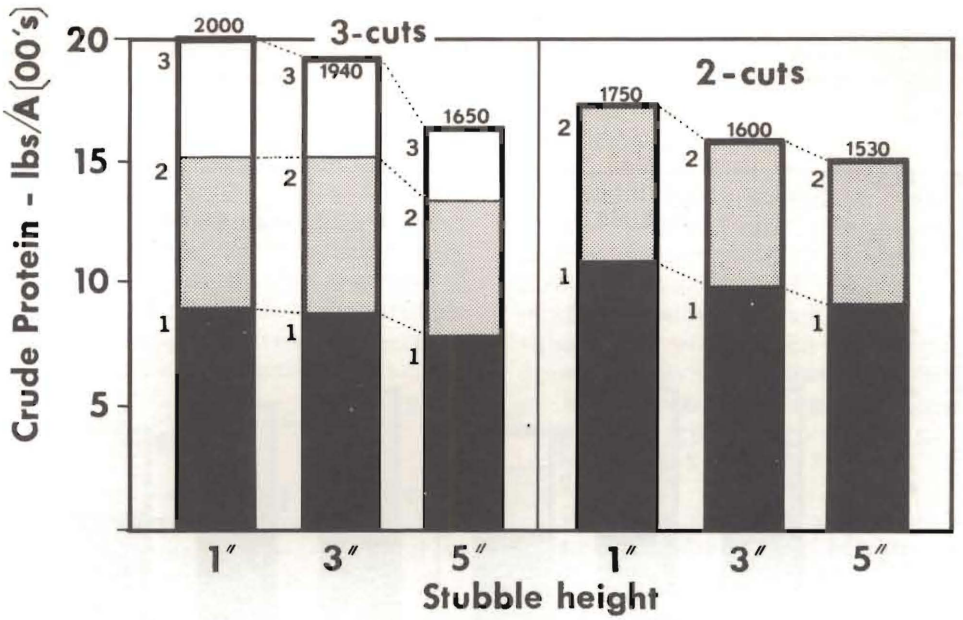

Figure 3. Total pounds crude protein produced per acre by Vernal alfalfa as influenced by stubble height and harvest frequency at Fargo, North Dakota, 1966-71.

Protein production per acre was increased by increasing the number of annual harvests from two to three (Figure 3). The 3-cut system averaged 239 pounds more protein/acre than the 2-cut system even though the dry matter yield from the 3-cut system was lower. The greater protein production during first harvest in the 2-cut system was more than compensated by the third harvest of the 3-cut system. The value of the additional protein production of a 3-cut system, especially at the 1- and 3-inch stubble heights, should return considerably more than the additional harvesting expense. Carter (1) found a similar increased protein production in four varieties under a 3-cut system.

Protein production per acre was decreased an average 142 pounds/acre (7.6 per cent) for each additional two inches of stubble height remaining in the field (Figure 3). The lower forage yield (0.32 tons/acre) from the 3-inch compared to 1-inch stubble height treatments under a 3-cut system was offset mostly by a higher per cent protein. Stubble height greatly influenced the per-acre protein production during the first two harvest years, primarily as a result of its influence on forage yield (Figures 2A and 2B). Protein production per acre was lowest following the severe 1967-68 winter injury because of lower forage yields; percentage protein in the hay was similar to the other years tested.

Per cent **in vitro** dry matter digestibility, a "test tube" measurement of dry matter disappearance using rumen fluids which estimates animal digestibility, increased with harvest frequency and stubble height (Table 3). Alfalfa hay cut twice was 4.1 and 4.4 per cent lower in digestibility than 3-cut alfalfa hay in the first and second harvests, respectively. First harvest forage may be slightly less digestible than second harvest forage for both harvest frequencies, especially from the 1-inch stubble height. The additional stubble height from 1 to 3 inches increased per cent IVDMD during the first harvest of both harvest frequencies but the additional stubble height from 3 to 5 inches did not increase per cent IVDMD. Increasing stubble height from 1 to 3 to 5 inches during the second harvest increased per cent IVDMD about 1.9 and

Table 3. Per cent in vitro dry matter digestibility of Vernal alfalfa hay as influenced by stubble height and harvest frequency at Fargo, North Dakota, 1968-71.

Harvest frequency	Stubble height	Harvest number[1]/ I	II	III
		—% in vitro dry matter digestibility[2]/—		
2-cuts				
	1-inch	60.4 a[3]/	61.3 a	
	3-inch	63.2 ab	63.9 b	
	5-inch	63.5 b	65.1 bc	
	Aug.	62.6 x	63.2 x	
3-cuts				
	1-inch	63.7 b	65.6 bc	67.8 a
	3-inch	67.8 c	67.6 cd	67.7 a
	5-inch	68.6 c	69.7 d	66.8 a
	Aug.	66.7 y	67.6 y	67.4
CV (%)		5.3	5.7	5.3

[1]/Average harvest dates: 3-cut—I=June 18, II=July 20, III=August 28; and 2-cut—I=July 4, II=August 28.

[2]/Determined using Tilley and Terry Method with modification for direct acidification.

[3]/Treatment means within a harvest and letter grouping (a-d or x-y) followed by the same letter are not significantly different at the 5% probability level.

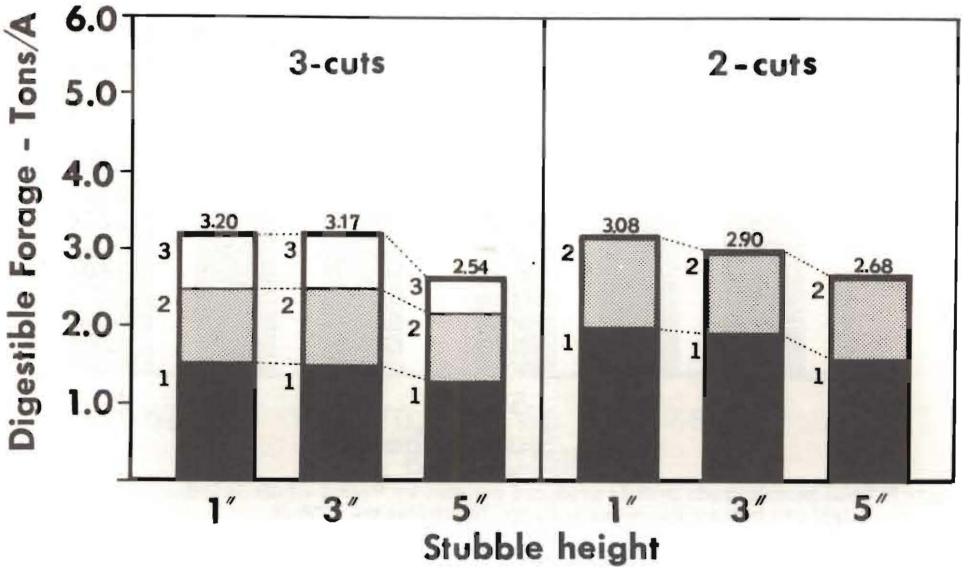

Figure 4. Total digestible forage produced per acre by Vernal alfalfa as influenced by stubble height and harvest frequency at Fargo, North Dakota, 1966-71.

2.0 percentage units for the 2- and 3-cut system, respectively. Third harvested forage per cent IVDMD was not influenced by stubble height. The 1-inch, 3-cut system produced forage as digestible as the 3- and 5-inch, 2-cut system forage during the first and second harvests.

Digestible forage per acre was increased by harvesting at lower stubble heights (Figure 4). Seasonal production of digestible forage was similar under the 1-inch, 2- and 3-cut systems and the 3-inch, 3-cut system. The higher per cent IVDMD of the 3-inch, 3-cut system compensated for the lower dry matter yield, whereas the higher dry matter yield compensated for the lower per cent IVDMD of the 1-inch, 2-cut system. The 3-cut system produced lower yields of digestible forage/acre than the 2-cut system for both the first and second harvests, but the additional 0.61 tons digestible forage/acre from the third harvest compensated for the lower yield. The 5-inch stubble height produced the lowest yields of digestible forage for both harvest frequencies except in 1968 following winter injury (Figure 2C). Harvest frequency as an average of stubble heights had little effect on annual digestible forage yields per acre (Figure 4).

Regrowth Rate

Stubble height did not affect regrowth rate. Plant maturity usually was similar and forage yields were lower for 5-inch compared to 1-inch stubble heights in the second and third harvests. Plant height in each harvest was similar among stubble heights for all treatments except the 5-inch, 3-cut treatment during the first harvest in 1968 which was significantly taller than the 1- and 3-inch stubble heights.

Stubble height and harvest frequency influenced the number of stems originating from crown buds as compared to axillary buds (Table 4). Regrowth originated primarily from crown buds under the 2-cut system. Regrowth from the 3- and 5-inch, 3-cut system had a significant higher number of new

Table 4. Per cent new stems originating from crown tissue following harvest as influenced by stubble height and harvest frequency at Fargo, North Dakota, 1967 and 1968.

Harvest frequency	Stubble height	1967		1968	
		Har II[1]/	Har III[2]/	Har II[1]/	Har III[2]/
		—% stems originating from crown[3]/—			
2-cuts					
	1-inch	100		100	
	3-inch	91		95	
	5-inch	93		90	
3-cuts					
	1-inch	100	100	100	100
	3-inch	80	50	75	75
	5-inch	66	33	95[4]/	70

[1]/*Regrowth after Harvest I.*

[2]/*Regrowth after Harvest II.*

[3]/*Remainder of stems originated from axillary buds on remnant stems of stubbles.*

[4]/*Harvest I of 5-inch, 3-cut system was several inches taller than the 1- and 3-inch stubble heights; subsequent lodging of 5-inch stubble plants resulted in few, if any, leaves remaining on stems.*

stems originating from axillary buds on remnant stubble stems, especially in the second regrowth, when lodging did not occur. The 3- and 5-inch stubble height treatments also had a greater number of stems/unit area, but these stems were less vigorous than those from 1-inch stubbles. If severe lodging and lower leaf loss occurred (5-inch, 3-cut system in 1968), axillary bud activity apparently decreased. These data may indicate that regrowth of more frequently harvested alfalfa at higher stubble heights may rely less on root reserves and more on photosynthetic activity by the remaining leaves.

Conclusions and Recommendations

The influence of stubble height and harvest frequency on alfalfa production, forage quality, winter survival and recovery rate was studied at Fargo, North Dakota, during 1966-71. Cutting at a 1-inch stubble height was chosen to simulate conventional mowing, while the 3- and 5-inch stubble heights were chosen to simulate swather harvesting.

Forage yields decreased approximately one-half ton dry matter per acre for each two inches of stubble height remaining after harvest. Recovery growth rate after harvest was not influenced by the cutting height. An increase in axillary bud activity on remnant stubble stems at higher cutting heights resulted in more stems/unit area and a higher quality forage. Assuming swather harvesting of alfalfa hay will continue due to its labor saving and economic advantages, these data suggest that it is imperative for operators to leave the least stubble that topography, stones, traveling speed, etc., will permit to obtain the maximum digestible forage and protein yield per acre. Forage yields from the 3-inch stubble height treatments were less influenced by the number of annual harvests than 1- and 5-inch stubble heights, especially after the first harvest year. A 3-inch stubble height appears to be a good compromise between forage quantity and quality and labor-saving machines.

The number of annual cuttings influences forage yield and quality. Three annual cuttings produced slightly less forage than two cuttings during this 6-year experiment, possibly a result of winter injury following the first and second harvest years. Three annual cuts produced more forage than two cuts in other Fargo tests (1). A higher quality, per cent IVDMD and per cent protein forage was produced by increasing the stubble height and harvest frequency, but digestible forage and protein per acre decreased with increasing stubble height. The 3-cut system should be utilized wherever rainfall allows, when it fits the management system, and when extra quality can be utilized effectively in livestock rations to help defer the additional harvest expense. Early cut, high quality alfalfa hay can provide an efficient, economic protein and energy source for ruminant livestock. Early cut alfalfa hay (i.e., 3- vs 2-cut system) utilized as a protein source to replace costly protein supplements will return 2- to 4-fold the additional harvest cost.

Alfalfa fields should be reseeded two to five productive years after establishment to obtain the highest forage yield and maximum soil benefits. First and usually second harvest years with normal rainfall produce higher forage yields than most subsequent years since the deep taprooted alfalfa draws on previously stored subsoil moisture. Alfalfa in crop sequences supplies some nitrogen to subsequent crops which may be a source of nitrogen in the future.

Winter injury may occur some years regardless of harvest management, but alfalfa can recover and produce acceptable yields if an adequate stand (three to four large plants per square foot) remains. Survival and vigor of alfalfa plants following winter injury was enhanced by higher stubble heights and the 2-cut system (delayed initial harvest). This may be a method to reduce effects of winter injury on alfalfa stands normally harvested under a 3-cut system.

Harvesting alfalfa at first flower to one-tenth bloom (three cuttings in eastern North Dakota or with irrigation in most of North Dakota, and two cuttings in lower rainfall areas) using a swather leaving a maximum 3-inch stubble should provide the highest obtainable yields of high protein, highly digestible alfalfa hay; the optimum alfalfa management for North Dakota.

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