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Fertilizing Brome Grass--Crested Wheat Grass in Western South Dakota

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Fertilizing Brome Grass-- Crested Wheat Grass

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Introduction

MORE SEED, MORE FORAGE and improved quality of hay are all possible in the semi-arid regions of western South Dakota if the right amounts of nitrogen and phosphorus fertilizer are applied to brome grass-crested wheatgrass.

This prediction of grass yields in relation to growing season rainfall comes after 6 years of research by State and Federal scientists at the Newell Field Station.[2]

Increased 1,353 Pounds Per Acre

Tests showed that not only did nitrogen and phosphorus increase forage yields by as much as 1,353 pounds per acre per year; but also, protein content of the grasses, harvested as hay, increased as much as 100%, and often carried through two seasons from one application. One year of high rates—up to 160 pounds per acre of nitrogen—gave increased forage yields for as long as 4 years.

Water played the biggest role, but temperature and relative soil fertility also influenced the response to fertilizer. In every case, as might be expected, the more moisture, the better the results of fertilization (see figures 1 and 2). However, in years of high seasonal temperatures hay yields may be substantially reduced. This effect of temperature on growth is more pronounced when nitrogen is used.[3]

More Water, More Yield

Yield increases per inch of rainfall ranged all the way from 87 to 346 pounds per acre. Head development, a good seed yield indicator, increased with fertilizer from 10 to

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[2]Contribution from Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Department of Agriculture in cooperation with the South Dakota Agricultural Experiment Station.

[3]Thomas, J. R., and Osenburg, A. 1959. Agronomy Journal Vol. 51:63-66.

31% in 1952, one of the drier test years. In 1953, the wettest year, increases were from 38 to 80%.

Testing Procedure

Tests were started in 1952 on a 12-year-old stand of brome grass-crested wheatgrass on a calcareous Pierre clay in the Newell area. Nitrogen as ammonium nitrate was applied at 0, 40, 80, and 160 pounds per acre to untreated land each year. A separate treatment was given—160 pounds of P_2O_5 as treble superphosphate in combination with 160 pounds of nitrogen.

Another group of plots received annually 20, 40, 80, and 160 pounds per acre of nitrogen for 4 years and 160 pounds of P_2O_5 in combination with 160 pounds of nitrogen. All treatments were applied in April.

Precipitation from March 30 to June 22 varied from 3.6 to 9.85 inches during the experiment. Mean seasonal rainfall for the 1952-1957 period was 5.92 inches.

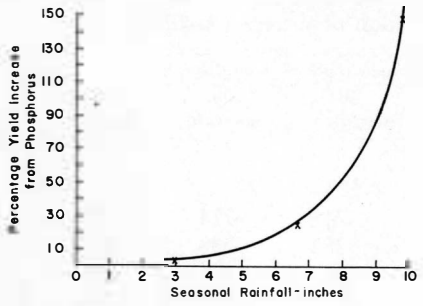

Figure 1.—Effect of seasonal rainfall on percent increase in yield from phosphorus fertilizer.

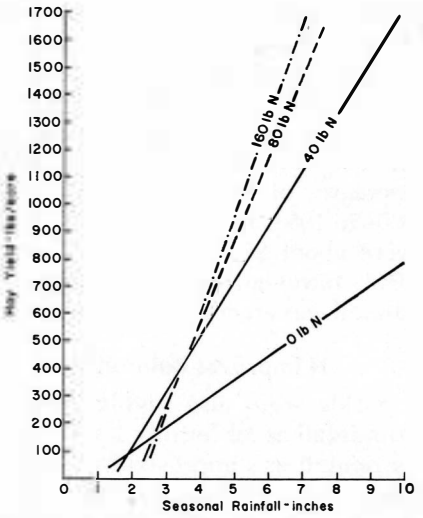

Figure 2.—Relation of seasonal precipitation to forage yields at different levels of nitrogen.

Yields Increased

Nitrogen fertilizer gave definite forage yield increases each year (see figure 3). Water, as mentioned, had the biggest effect on total increase. In 1952 and 1955, when rainfall was below normal, 40 pounds of nitrogen increased yields by 157 and 196 pounds. With more favorable rainfall, 1953 and 1954, 40 pounds of nitrogen increased yields by 900 and 584 pounds.

N Carries Over

Nitrogen not used by plants one year carried over and contributed to yield in following years. The amount of nitrogen first applied and its immediate use determined the amount carried over. In other words, the more fertilizer used immediately by grasses, the less later available. Grass given 160 pounds of nitrogen in 1952 responded to

residual nitrogen each year through 1956. Those given 80 pounds showed significant forage increases for only one season. Residual nitrogen from the 1952 applications of 40, 80, and 160 pounds gave yield increases of roughly 53, 157, and 265% in 1953. Yield increases in 1954 were about 23, 55, and 155% from 1953 nitrogen carryovers. Again, rainfall was an important factor.

N Improves Rainfall Use

Yields were also highly related to rainfall at all fertility levels. Use of rainfall was improved by the application of nitrogen fertilizer. Hay yields per acre increased 87, 201, 306, and 344 pounds for every inch of additional rainfall for the 0-, 40-, 80-, and 160-pound nitrogen applications respectively (see figure 2).

Phosphorus fertilizers significantly increased forage yields only during years of relatively high rainfall (see figure 1), or when amount applied exceeded 20% of the phosphorus adsorption capacity of the soil—226 pounds of P_2O_5 per acre. Residual phosphorus from the 320 pounds of P_2O_5 previously applied produced 466 pounds of hay in 1954.

Rainfall Major Factor

Table 1 shows the forage yields that can reasonably be expected with various combinations of nitrogen fertilizer and seasonal rainfall. Increasing yields with 40 pounds of nitrogen fertilizer required about 2 inches of precipitation. To obtain an economical return from the 40-pound nitrogen addition about 6 inches of rainfall were necessary. Rainfall records for the 51 years, 1909-1960, show that seasonal rainfall exceeded the 6-inch level 50% of the time. Nine inches of seasonal precipitation were needed for an economical return from 80 pounds of nitrogen. Probability of 9 inches of rainfall being received during the growing season was 1 in 5.

One Application Best

Total yields and value of hay produced with one and four fertilizer applications are shown in table 2.

Table 1. Brome grass-crested wheatgrass yields predicted from estimated seasonal precipitation and application of nitrogen fertilizer.

Estimated seasonal* precipitation inch	Nitrogen applied—pounds per acre			
	0 lbs./acre	40 lbs./acre	80 lbs./acre	160 lbs./acre
1	17	—	—	—
2	104	123	—	—
3	191	324	273	274
4	278	525	580	620
5	365	726	886	966
6	452	927	1,192	1,311
7	539	1,128	1,498	1,657
8	626	1,329	1,804	2,003
9	713	1,530	2,111	2,349
10	800	1,731	2,417	2,695

*Seasonal precipitation March 30 through June 30.

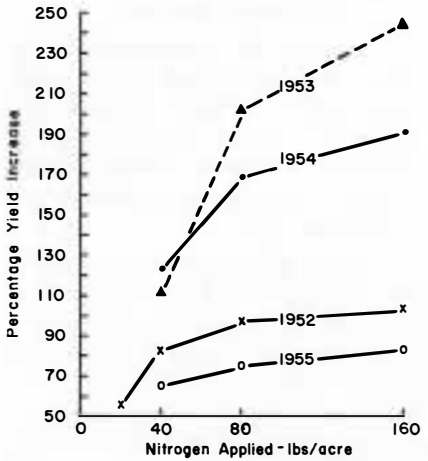

Figure 3.—Effect of nitrogen fertilizer on forage yields as influenced by climatic conditions in different years.

More forage was produced by adding a large amount of fertilizer once than by applying smaller amounts every year. Use of fertilizer on dryland grasses cannot be justfied in terms of the pounds of hay produced. Monetary returns above the value of the nonfertilized hay yields were not quite sufficient to pay for the fertilizer. If, however the value of the extra protein produced can be truly represented by the crude protein content, the use of fertilizer is quite profitable, as shown in table 2.

Nitrogen Affects Phosphorus Content

Nitrogen fertilization in all cases reduced the phosphorus content of the grass (see figure 4). The more nitrogen added, the more reduction in phosphorus, due to the increase in crop growth. Phosphorus content of the grass increased, however, with more rainfall, indicating that soil moisture conditions largely determine the uptake of soil phosphorus. On phosphorus-deficient soils the addition of phosphorus fertilizer along with nitrogen will offset the depressive action of nitrogen on the phosphorus content of the grass.

Forage yields were directly related to the nitrogen content and inversely related to the phosphorus content of the grass at harvest.

Nitrogen Recovery

The largest percent recovery was in 1953—from 1952 treatments (see table 3). Percentage recovery of nitrogen increased with levels of application. Total recovery of nitrogen applied in 1953 was slightly higher than for the 1952 nitrogen additions. This was due mainly to the greater utilization of the direct ni-

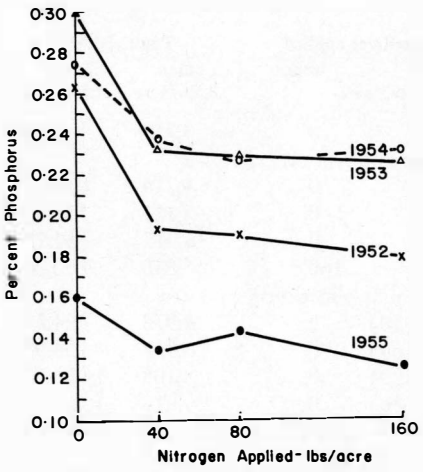

Figure 4.—Effect of nitrogen fertilizer on the phosphorus content of hay.

trogen application in 1953—a wet year.

Recovery of the 40 and 80 pound nitrogen was not increased much by continuous cropping.

Comparison of the 160-pound nitrogen treatment with the 160-pound nitrogen plus 160-pound phosphorus treatment of 1953 shows that phosphorus increased nitrogen uptake from 45.9 to 63.4%. The same effect of phosphorus on nitrogen recovery was found in other years.

Fertility—Moisture Relationships

The pattern of water use in 1954 showed that the water supply in the surface 6 inches of soil was used more rapidly if the fertility was high. At lower depths (2-3) feet) nitrogen did not affect rate of water use. Moreover, water use efficiency was increased by the use of nitrogen.

Protein Content

Generally, the more nitrogen applied, the higher the protein content of the harvested grasses (see figure 5). Single additions were as effective as annual nitrogen treatments in raising the protein levels of the grasses.

As rainfall increased, the percent protein usually went down. For example, 40 pounds of nitrogen in a dry year increased protein from 8.17 to 14.59%; whereas, in 1953, with more rainfall, 40 pounds of nitrogen increased the protein from 9.86 to 10.63%.

Just the opposite occured on non-fertilized grass—that is, as rainfall increased, protein content went up, indicating that conditions were more favorable for the mineralization of soil organic matter.

Data of table 2 show that the increase in yield of protein associated

Table 2. Total yield and value of hay and crude protein.

Fertilizer applied		Total yields*		Fertilizer†	Total value of		Return above check and fertilizer cost	
N	P_2O_5	Hay	Protein	cost	Hay‡	Protein§	Hay	Protein
Lbs./acre		Lbs./acre	Lbs./acre	Dollars	Dollars	Dollars	Dollars	Dollars
0	0	3,565	335.90	0	26.70	43.67	—	—
Single application								
40	0	4,214	414.81	6.00	31.50	53.93	–1.20	4.26
80	0	5,111	531.45	12.00	38.25	69.09	–0.45	13.42
160	0	6,917	844.19	24.00	51.75	100.74	1.05	42.07
160	160	6,840	850.24	38.40	51.30	110.53	–13.80	28.46
Annual applications‖								
20 (80)	0	4,973	494.53	12.00	37.20	64.29	–1.50	8.62
40 (160)	0	6,577	754.97	24.00	49.20	98.15	–1.50	30.48
80 (320)	0	8,105	1,096.58	48.00	60.75	142.56	–13.95	50.89
160 (640)	0	9,614	1,462.78	96.00	72.00	190.16	–50.70	50.49
160 (640)	160 (640)	11,683	1,808.93	153.90	87.60	235.16	–93.00	37.59

*Yields from 1952 through 1957 on ovendried basis.
†Nitrogen cost at $0.15 a pound, phosphorus at $0.09 a pound.
‡Hay valued at $15.00 a ton.
§Protein valued at $0.13 a pound.
‖Applied each year 1952 through 1955.

Table 3. Percent of fertilizer nitrogen recovered at various periods.

Fertilizer applied		Year	Nitrogen recovered*		
N	P_2O_5	applied	1952-53	1952-54	1952-57
Lbs./acre			%	%	%
0	0				
Single applications					
40	0	1952	31.1	32.2	31.6
80	0	1952	35.7	38.4	39.1
160	0	1952	40.4	45.4	50.8
160	160	1952	42.1	45.9	51.4
40	0	1953		41.1	40.3
80	0	1953		46.4	44.5
160	0	1953		41.1	45.9
160	160	1953		57.1	63.4
Annual applications					
20 (80)	0	1952–55	32.2	36.4	31.8
40 (160)	0		39.9	41.2	41.9
80 (320)	0		36.1	33.3	38.1
160 (640)	0		21.4	21.2	26.1
160 (640)	160 (640)		30.5	32.3	36.8

*Calculated from the relation: $\frac{\text{total N - total N in check}}{\text{Total N applied}}$

with the use of nitrogen more than paid fertilizer cost.

Phosphorus Effect on Protein Content

The effect of phosphorus fertilizer on grass protein content did not follow a definite pattern. In years of low rainfall, 1952 and 1955, the addition of phosphorus with nitrogen increased protein more than nitrogen alone. In 1953 and 1954, when rainfall was greater, phosphorus had little or no effect on protein.

Residual Nitrogen Effect on Protein

Residual nitrogen from the 40-pound treatment had no effect on protein even though hay yields were increased. Nitrogen carryover from the 80 pounds of nitrogen applied in 1954 produced higher protein for one season. However, 80 pounds of nitrogen put on in 1952 and 1953 had no effect on protein the following year. Residual effects of the 160-pound nitrogen additions

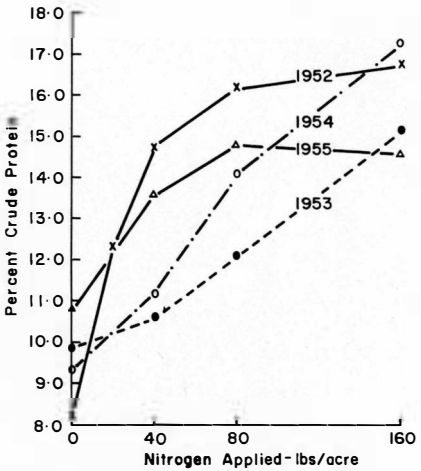

Figure 5.—Effect of nitrogen fertilizer on crude protein content of hay.

on protein were evident for 1 to 2 years.

Summary

Hay yields were greatly increased by nitrogen fertilizer. The highest rates of nitrogen gave the greatest residual response in the 4 years following application.

Effect of seasonal rainfall on hay production was determined by fertility of the soil. Yield increases per inch of water were from 87 to 344 pounds per acre.

Grasses responded well to phosphorus fertilizer when rainfall was high and when the amount of fertilizer applied satisfied 20% of the soil's phosphorus absorption capacity.

Protein content was increased by nitrogen and lowered with increasing rainfall. Nitrogen carry-over from the 160-pound treatment increased protein content for two years. Additions of phosphorus increased protein only in years of low rainfall.

Hay yield increase alone from fertilizers was not sufficient to justify their use. However, quality of hay greatly improved.

High Yields—High Protein

Forage yields were related to the percentage of nitrogen and phosphorus in the grass. In years of low rainfall, nitrogen was from 3 to 21 times more effective than phosphorus in determining yields. High hay yields were associated with high protein.

Recovery of nitrogen was affected by amount applied, seasonal rainfall, and amounts of other nutrients in the soil. The greatest recovery, 63.4% was made with the 1953, 160-pound nitrogen, 160-pound phosphorus treatment.

High soil fertility caused water to be used faster from the surface 6 inches of soil, but had no effect on moisture from lower depths.