Nitrogen and Phosphorus Fertilization of Cool Season Grass

Jim Gerwing, Ron Gelderman, Ed Twidwell
South Dakota State University
Plant Science Department
Brookings, South Dakota

Abstract

Studies were initiated at two locations on cool season grass in central South Dakota to evaluate the effects of nitrogen and phosphorus on forage and seed yields. Nitrogen rates (0,30,60,90,120,150lb N/acre) and phosphorus rates (0,30,60,90,180 lb P_2O_5/acre) were applied to established crested or intermediate wheatgrass once and harvested for either two or three years depending on location. Nitrogen increased dry matter yield by 48 and 62% at the two locations and seed yield by 166 percent. Phosphorus soil test levels were medium or low. Phosphorus fertilizer did not result in highly significant yield increases at any of the five site years. Three years combined yields at one location did result in significant yield increases. Phosphorus had no effect on crested wheatgrass seed yield.

Objectives

There is approximately 26 million acres of grassland in South Dakota. It is estimated that less than 5% of the grassland is fertilized. Earlier research in South Dakota has shown, however, that forage yields of cool season grass can be nearly doubled with nitrogen fertilizer. Grasses such as crested wheatgrass and intermediate wheatgrass produce most of their growth during the early spring and respond well to late fall or early spring applications. The nitrogen portion of this work was done to 1) demonstrate the effectiveness of nitrogen applications for cool season grass forage production and to 2) investigate the influence of nitrogen on grass seed yield.

Most grassland in South Dakota has never received phosphorus fertilizer. Phosphorus soil test levels in grasslands are usually low or occasionally medium. Limited previous research in South Dakota has shown cool season grass responds to phosphorus fertilizer. More research is needed, however, to determine if soil test phosphorus is well correlated to yield response from P fertilizer. The objectives of the phosphorus portion of these studies were to determine the influence of added phosphorus on 1) cool season grass forage and seed yields 2) phosphorus uptake by cool season grass and 3) soil test P levels under established grass.

Methods

Studies were initiated in Hyde County in 1988 and Jones County in 1990. The soil at the Hyde County site is classified as a Highmore. These soils are silt loams formed from a silty glacial drift and are typical of those found in central South Dakota east of the Missouri River. The site had a good stand of crested wheatgrass estimated to be 15

years old. Soil at the Jones County site is classified as a Promise Clay. These soils are deep well-drained nearly level clayey soils on uplands. They were formed from the Pierre shale and are typical of the heavy textured soils in central South Dakota west of the Missouri River. The site had a relatively thin stand of Oahe intermediate wheatgrass which was approximately 10 years old. Very little fertilizer or manure was applied to either location over the last 15 years which is typical of most grass stands. Both locations had been hayed and or grazed for the last 10-15 years.

Soil test levels at the beginning of the studies are given in Tables 1 and 2. Nitrate soil test levels were very low at both locations which is typical of perennial grass stands. Phosphorus soil test levels were low at the Jones site and low to medium at the Hyde County site. Both locations had low P soil test levels in the subsoil. Soil pH was 6.7 at the Hyde County site and 7.9 at the Jones County site. The high pH at the Jones site is normal for many heavy soils west of the Missouri River.

Table 1. Soil Tests, Crested Wheatgrass Fertilization, Hyde County, March, 1988

Depth	NO_3-N	P[1]	K	OM	pH	Salts
inches	----------ppm----------			%		mmho/cm
0-3	2	12	720	4.7	6.7	0.3
3-6	1	5	600	3.8	6.6	0.3
6-9	1	3	460	3.0	6.6	0.3
9-12	1	3	440	2.4	6.7	0.2
12-24	1	5	460	1.8	6.8	0.3

1 Bray I Test

Table 2. Soil Tests, Intermediate Wheatgrass Fertilization, Jones Co. March, 1990

		P					
Depth	NO_3-N	Bray	Olsen	K	OM	pH	Salts
inches	----------ppm----------				%		mmho/cm
0-3	4	7	3	600	3.3	7.9	.70
3-6	3	3	1	420	3.2	7.9	.60
6-12	2	3	2	398	2.8	8.0	.60

Nitrogen and phosphorus fertilizer treatments are listed in Table 3. Fertilizer treatments were applied the first year with subsequent years measuring only the residual effect. Nitrogen rates ranged from 0 to 150 lb N/A and phosphorus rates ranged from 0 to 180 lb/A. The Hyde County P study received 60 lb N/acre in 1988 and 1989 and 90 lb N/acre in 1990. The Jones County P study received 90 lb N/acre in 1990 and 1991. The Hyde County N study received 60 lb P_2O_5/acre in 1989. The Jones County N study received no additional P fertilizer. The adjacent phosphorus study, however, showed no response to additional P. The phosphorus source used in Hyde County was triple super

phosphate (0-46-0) and in Jones County it was diammonium phosphate (18-46-0). In Jones County the N supplied with the phosphorus fertilizer rate was balanced with Urea N. The source of N for all experiments was urea. All fertilizer materials were broadcast on the surface by hand in late March or April. Plot size was 15 feet by 15 feet. A randomized complete block design was used. Each treatment was replicated four times.

Table 3. Fertilizer Treatments, Cool-Seasons Grass, Hyde and Jones County 1988-1991

A) Nitrogen		
1)	Hyde Co:	1989 - 0, 30, 60, 90, 120, 150 lb N/A
		1990 - residual harvest
2)	Jones Co:	1990 - 0, 30, 60, 90, 120 lb N/A
		1991 - residual harvest
B) Phosphorus		
1)	Hyde Co:	1988 - 0, 30, 60, 90, 180 lb P_2O_5/A
		1989, 1990 residual harvest
2)	Jones Co:	1990 - 0, 30, 60, 90, 180 lb P_2O_5/A
		1991 - residual harvest

Forage yield was taken once per year when grass was headed and full forage growth had been achieved. Harvest dates were in mid to late June for crested wheatgrass and July for intermediate wheatgrass. Forage harvest was accomplished by harvesting either a 20 square foot or 36 square foot area with a commercial duty lawn mower or a sickle bar mower respectively. The crested wheatgrass seed yield was estimated in 1988 and 1990 by clipping the heads from a one meter square area. Seed yields were not taken in 1989 due to hot, dry conditions that limited seed formation.

Spring (mid March to Mid June) rainfall at the Hyde County site was approximatly 5.5 inches in 1988 and 1989. Even though this was near normal, moisture stress resulted from extremely hot May and June temperatures. Spring rainfall in 1990 at this site was less than average (3.5 inches) but cool temperatures minimized moisture stress resulting in larger forage yields than in 1988 or 1989. Rainfall at the Jones County site in 1990 and 1991 was above normal and moisture stress was minimal.

Results and Discussion

The influence of nitrogen on cool season grass dry matter production at the Hyde and Jones County sites is displayed in Table 4. Nitrogen significantly increased yield at both sites each year. At Hyde County in the high stress year of 1989, crested wheatgrass yields almost doubled. The total forage increase to fertilizer N the following year (residual effect) was almost equal to the first year response. This indicates applied nitrogen was still plant available one year after application. Nitrogen applications at these locations would return more than two dollars for each dollar invested in fertilizer.

Table 4. Influence of Nitrogen on Cool-Season Grass Dry Matter Production, Hyde and Jones County 1989-1991

Nitrogen Rate[1]	Dry Matter Yield					
	Hyde County			Jones County		
	1989	1990	Total	1990	1991	Total
lb/A	----------lb/A----------			----------lb/A----------		
0	2034	3758	5792	3053	2580	5633
30	2957	4012	6969	3653	3015	6668
60	3507	4070	7577	3895	3316	7211
90	4037	4545	8582	4352	-	-
120	3924	4687	8611	4455	3899	8354
150	3972	5407	9379	-	-	-
Prob. >F	0.0001	0.001	0.0001	0.025	.013	
LSD .05	735	312	955	860	699	

1 N applied first year only, 2nd year is residual effect

Nitrogen fertilization also caused significantly increased forage protein levels at each location. Nitrogen content of plant tissue increased from 1.29% in the check at the Hyde County site to 1.78% with 150 lbs N applied (Table 5). Protein yield per acre estimated from N content (% N x 6.25 = % protein) at this site increased from 164 lb/A in the check to 442 lb/A with the high N rate.

Table 5. Influence of Nitrogen Fertilizer on Nitrogen Content of Cool-Season Grass Hyde and Jones County

Nitrogen Rate	Nitrogen Concentration	
	Hyde County 1989	Jones County 1990
lb/A	----------%	----------
0	1.29	.99
30	1.22	.95
60	1.29	.99
90	1.46	1.20
120	1.52	1.15
150	1.78	-
Pr > F	0.0001	0.001
CV %	7.4	7.2

The influence of residual nitrogen on crested wheatgrass seed yield is listed in Table 6. Seed yield increased from 97 lb/A with no nitrogen fertilizer to over 250 lbs per acre with higher N rates. Increases in seed yield can be extremely profitable to farmers in years when the demand for seed exists. In the mid to late 1980's, farmers were receiving over $2.00 per pound for crested wheatgrass seed.

Table 6. Influence of Nitrogen on Crested Wheatgrass Seed Yield, Hyde County, 1990

Nitrogen Rate	Seed Yield
----------lb/A----------	
0	97
30	124
60	137
90	216
120	284
150	258
Prob > F	0.0001
CV %	25

Nitrogen fertilizer applied in the spring of 1989 did not result in increased nitrate soil test levels one year later in Hyde County (Table 7) even though the high application rate exceeded grass removal by over 100 lb/A. That is an indication of the potential for immobilization of N by grass sod and is one of the reasons the nitrate soil test is not well correlated to nitrogen needs of grass. Some of this N mineralized in 1990, resulting in significant increases in forage and seed yields (Table 4 and 6). Nitrogen loss by leaching was not likely due to dry conditions during 1989.

Table 7. Influence of Nitrogen Fertilizer Rate on Nitrate Soil Test Level in Grass, Hyde County

	Nitrate Soil Test [1]					
	Nitrogen Rate, lb/A [2]					
Depth	0	30	60	90	120	150
inches	----------ppm NO_3-N----------					
0-6	2.6	2.8	2.4	2.6	3.2	3.2
6-12	.8	.8	1	1	1	1.2
12-18	.6	.6	.6	.6	.6	.8

1) Sampled March, 1990
2) Applied March, 1989

Phosphorus fertilizer had some positive effect on forage yield in 2 out of 3 years at the Hyde County site (Table 8). There was not a significant increase in yield to residual phosphorus the third year (1990). However, total dry matter yields over the three year period did increase with increasing phosphorus levels. There was no significant increases in yield due to phosphorus application in either 1990 or 1991 at the Jones County site, even though soil test levels were low (Table 8).

Table 8. Influence of Phosphorus on Cool-Season Grass Dry Matter Production, Hyde and Jones County 1988-1991

	Dry Matter Yield						
Phosphorus	Hyde County				Jones County		
Rate[1]	1988	1989[1]	1990[1]	Total	1990	1991[1]	Total
lb P_2O_5/A	lb/A				lb/A		
0	2019	2767	5718	10,503	4352	5408	9760
30	2038	3398	6044	11,479	4354	5810	10164
60	2200	2928	6066	11,194	4753	6358	11111
90	2054	3406	5921	11,381	4910	6281	11191
180	2317	3892	6322	12,531	4852	6439	11291
Prob > F	0.13	0.06	0.37	0.006	0.37	0.27	
LSD .05	269	-[2]	629	905	776	1117	

[1] P applied first year only, following years are residual effect
[2] LSD not computed due to missing value.

The data from these two locations over the four year period indicates grass does not respond to phosphorus fertilizer on lower testing soils as readily as other crops. In addition, the responses that did occur were relatively small, making it more difficult to justify P fertilizer additions under these situations. The small increases in annual yields due to residual phosphorus may continue for many years, however, making the profit potential more positive.

Phosphorus content in the plant tissue was significantly increased with increasing P fertilizer rates at the Hyde County site but not at the Jones County site. (Table 9) The increase in tissue P concentration was only noted at the Hyde County site where dry matter yield also increased. Phosphorus concentration in the tissue at the Jones County site was well below the .15-.20% P normally considered adequate for grass. Even though moisture was adequate, the intermediate wheatgrass did not effectively use the topdressed fertilizer P at this site.

Table 9. Influence of Phosphorus Fertilizer on Phosphorus Concentrations in Cool Season Grass, Hyde and Jones County

P_2O_5 rate	Phosphorus Concentration: Hyde County [1] 1988	Hyde County [1] 1989	Hyde County [1] 1990	Jones County 1990
lb/A	----------	%	----------	%
0	0.120	0.134	0.131	0.074
30	0.138	0.152	0.133	0.079
60	0.140	0.168	0.142	0.071
90	0.145	0.171	0.156	0.081
180	0.155	0.188	0.173	0.088
Pr > F	0.004	0.01	0.004	0.16
CV %	6.9	11.3	9.3	11.5

1 Phosphorus applied in 1988 only

The influence of phosphorus fertilizer on crested wheatgrass seed yield is displayed in Table 10. Even though there was an increase in tissue P concentration each year and a small increase in forage yield in 1988, there was no increase in crested wheatgrass seed yield due to phosphorus fertilizer in Hyde County in 1988 or 1990.

Table 10. Influence of Phosphorus on Crested Wheatgrass Seed Yield, Hyde County, 1988, 1990

Phosphorus rate	Seed Yield 1988	Seed Yield 1990
lb P_2O_5/A	----------	lb/A ----------
0	108	316
30	133	346
60	119	346
90	138	330
180	104	293
Prob > F	0.63	0.57
CV %	30	15

The results of phosphorus soil test analysis taken after harvest in 1988 in two inch depth increments show most phosphorus remained in the top two inches of soil (Table 11). The dry conditions of central South Dakota may be limiting active root growth in this soil layer and therefore phosphorus uptake, minimizing the effect of phosphorus fertilizer. Deeper placement of P fertilizers may result in larger yield increases on these P deficient soils.

Table 11. Phosphorus Soil Test Levels After Broadcast Applied Phosphorus to Cool Season Grass, Hyde County, 1988

P_2O_5 Rate[1]	Phosphorus Soil Test[2] depth, inches 0-2	2-4	4-6
lb/A	----------ppm----------		
0	14	4	3
30	22	6	3
60	27	7	3
90	39	8	3
180	50	10	4

1 Applied Spring, 1988
2 Sampled fall, 1988

The phosphorus analysis on soil samples taken to a six inch depth after harvest in 1990 at both locations are given in Table 12 along with soil tests taken at the Hyde County site in the fall of 1988. Both the Bray and Olsen P test increased with increasing fertilizer rates in a predictable manner.

Table 12. Phosphorus Soil Test Level, Cool-Season Grass Studies, Hyde and Jones County, Fall Sampling, 1988-1990

P_2O_5 rate[1]	Phosphorus Soil Test: Hyde County Bray I 1988	Hyde County Bray I 1990	Hyde County Olsen 1990	Jones County Bray I 1990	Jones County Olsen 1990
lb/A	----------ppm, 0-6 inches----------			--ppm, 0-6 inches--	
0	7	5	2	4	3
30	11	7	3	5	3
60	13	10	5	6	5
90	17	14	7	9	5
180	22	19	11	14	12

1 Phosphorus applied only once, March 1988 in Hyde Co. and March, 1990 in Jones Co.

Conclusions

1) Nitrogen fertilizer produced large and very profitable cool season grass forage yield increases.

2) Nitrogen Fertilizer produced very large crested wheatgrass seed yield increases.

3) Phosphorus fertilizer did not increase cool season grass forage yield as much as predicted by current grass soil test calibration.

4) Phosphorus fertilizer did not increase crested wheatgrass seed yield.

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Department of Agronomy
Department of Agronomy
Iowa State University
Ames, IA 50011