INFLUENCE OF PHOSPHORUS ON THE YIELD AND PROTEIN CONTENT OF ARROWLEAF CLOVER IN A NATIVE TALLGRASS PRAIRIE

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Story in Brief

Arrowleaf clover was overseeded into a native tallgrass prairie site. Yield increased greatly with increasing phosphorus from P_2O_5. No difference existed in yield between the control (no phosphorus) and low phosphorus (40 lb/acre) treatments, but 80 lb/acre resulted in approximately twice as much clover yield, whereas 120 and 160 lb increased yields about three times. In one year, grass yields were reduced substantially (average of 31% as much grass) on the arrowleaf clover plots compared to the control, whereas in the second year there was little difference in grass production. Much less grass production in one year was probably due to only about one-third as much rainfall that summer. In the second year, rainfall approximated the long time average for the summer months for that location. Yet, even in the drier year, total production (clover + grass) averaged about twice as great on the clover plots. Weeds were substantially reduced in the clover plots. Arrowleaf clover contained from 16.5 to 18.1% crude protein in May, declining to about 11% in early June in Year 1. Protein values in June of Year 2 were about 14%. Highest protein values were obtained for clover on the highest phosphorus levels, reflecting higher protein content in the leaves.

(Key Words: Arrowleaf Clover, Phosphorus, Yield, Protein, Tallgrass Prairie.)

Introduction

In recent years, arrowleaf clover (Trifolium vesiculosum savi.) has received much interest in the southeastern U.S. where survival and productivity are not limited by rainfall. Adding clover to an established native grass pasture may improve the pasture by increasing yield, crude protein content and, in some cases, length of the grazing season. Arrowleaf clover offers earlier production in the spring, has a longer growing season, is more drought tolerant and insect resistant and has a lower bloat potential than many other clovers. Because of rainfall, arrowleaf clover appears to offer the most potential in the eastern one-half of Oklahoma, yet little or no data on yield or nutritive characteristics have been reported for arrowleaf clover grown in a native tallgrass range site. The objectives of this study were to determine 1) the yield of phosphorus fertilized arrowleaf clover grown in a native tallgrass prairie and 2) the crude protein content and leaf:stem ratio of the arrowleaf clover.

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Materials and Methods

Yuchi arrowleaf clover was overseeded into a native tallgrass prairie which consisted mostly of big bluestem, little bluestem, switchgrass and indiangrass at the O.S.U. Agronomy Research Range west of Stillwater, Oklahoma. Different seeding and phosphorus application rates were used to determine their potential influence on the yield and quality of arrowleaf clover. There were seven treatments (Table 1), with four replications per treatment. Each plot was approximately 20 x 50 feet (6 x 15 meters). Fertilizer was applied in August, 1981 at rates of 0, 40 or 80 lb of phosphorus (P) per acre from P_2O_5. Plots were seeded in October, either 10 or 20 lb per acre, of the same year. No visual difference in the density of stand of arrowleaf clover appeared to exist the first year following seeding at the low and high seeding rates. Plots were not mowed until September, 1982 to allow reseeding of the arrowleaf clover. In 1983, data from another trial (Westermann, 1984) indicated that 80 lb of P per acre did not permit top yield, so an additional 80 lb of P per acre from P_2O_5 were applied to two plots (as denoted in Table 1) in 1983 to permit evaluation of even higher P levels. Thus, P levels were 0, 40, 80 and 120 (40 + 80) or 160 (80 + 80) P.

Samples from each plot were hand clipped on May 4, 1984, June 4, 1984 and June 7, 1985. The entire plots were mowed to a 5 inch (13 cm) stubble height in early June (same dates as sampling) to determine clover yield. Grass yields in August were determined by hand clipping. All clover plots were mowed to a uniform height in September to allow clover establishment. Control plots were not mowed in September. Samples were hand separated into grass and clover. Clover was further divided into leaf and stem portions. After dry weight was determined for each portion, samples were ground and crude protein content determined. Neutral and acid detergent fiber, lignin and ash measurements were made as well, but are not reported herein. Yield data were acquired and provided by McMurphy and co-workers in the O.S.U. Agronomy Department.

Table 1. Seeding and phosphorus application rates for arrowleaf clover in native tallgrass prairie.

Treatment	Arrowleaf clover seed[a]	Phosphorus
	lb/acre	
Control	0	0
0 P	10.0	0
120 P	10.0	40[b]+80[c]
160 P	10.0	80[b]+80[c]
0 P	20.0	0
40 P	20.0	40[b]
80 P	20.0	80[b]

[a]Clover seeded October, 1981.
[b]P_2O_5 applied August 25, 1981.
[c]P_2O_5 applied September 16, 1983.

Results and Discussion

Yield

A substantial increase ($P<.05$) was noted in yield of arrowleaf clover with increasing P (Table 2). Yield of clover was not different between the 0 P and 40 P treatments, but plots receiving 80 lb of P per

Table 2. Biomass dry matter removed per acre from tallgrass native range pasture overseeded with arrowleaf clover.

	Arrowleaf clover							
	June[1]	August[2]	Total		Grass		Weedy forbs		Total[3]
	---------lb---------			%[4]	lb	%[4]	lb	%[4]	lb
				Year 1 (1984)					
Control	---	---	---		2425	(83.8)	467	(16.2)	2892
0 P[5]	1518	479	1997	(64.9)	1022	(33.2)	59	(1.9)	3078
120 P	5759	465	6224	(84.3)	1127	(15.2)	42	(.5)	7393
160 P	6532	674	7206	(87.6)	974	(11.9)	42	(.5)	8222
0 P[6]	1428	819	2247	(78.9)	554	(19.4)	49	(1.7)	2850
40 P	1501	744	2245	(81.4)	510	(18.5)	5	(.1)	2760
80 P	2995	829	3824	(87.4)	406	(9.2)	153	(3.4)	4383
				Year 2 (1985)					
Control	---	---	---		2994	(81.9)	658	(18.1)	3652
0 P[5]	1682	160	1842	(40.4)	2638	(57.7)	88	(1.9)	4568
120 P	5346	340	5686	(66.8)	2788	(32.7)	45	(.5)	8520
160 P	4877	339	5216	(63.7)	2831	(34.5)	148	(1.8)	8195
0 P[6]	1582	371	1954	(38.6)	2995	(59.2)	116	(2.2)	5064
40 P	1821	537	2358	(49.1)	2320	(48.4)	125	(2.5)	4802
80 P	2929	393	3322	(51.9)	2570	(40.0)	520	(8.1)	6412

[1]Harvested in early June (June 4 in Year 1, June 7 in Year 2).
[2]Harvested mid-August.
[3]Total of clover, grass and forbs.
[4]Percentage of total biomass removed.
[5]10 pounds of seed per acre.
[6]20 pounds of seed per acre.

acre produced nearly twice ($P<.05$) as much clover, whereas the 120 or 160 P treatments produced nearly three times ($P<.05$) as much clover. Responses in yield of clover were quite similar between years, although the advantage was slightly less in 1985 on the two highest P treatments.

In 1984, grass production (Table 2) was two to five times higher ($P<.05$) on the control plot (0 clover, 0 P) than on plots containing arrowleaf clover. Generally lowest grass yields were obtained on the arrowleaf clover plots receiving either no P or intermediate P (40 or 80 P) levels. However, in 1985, there was little difference among treatments in grass yields, and yields on the arrowleaf clover plots were substantially higher (3 to 5 times) than in the previous year (1984). The greatly improved grass production in 1985 can likely be attributed to nearly three times higher rainfall during that summer (12.7 inches during June, July, and August, 1985) than in 1984 (4.75 inches, 1984). The long term average rainfall for these three months at this location is 11.8 inches, similar to that obtained in 1985. Thus, these data suggest that in years of adequate rainfall, the presence of arrowleaf clover may not greatly depress grass production. In 1985, an average of 89% as much grass yield was obtained on the clover plots as on the control. However, in drier years, it appears that competition for moisture early in the growing season may greatly depress subsequent grass yields. In 1984 when rainfall was much less, grass yields averaged only 31% as much on the arrowleaf clover plots compared to the control. Yet, even in this year, total forage production (clover plus grass) was almost twice as high on an average for the 6 clover plots (4722 lb/acre) compared to that of the control (2425 lb/acre). During 1985, total production was more than twice as great on an average for the 6 clover plots. Additionally, a substantial decrease ($P<.05$) was noted in the presence of weedy forbs in the clover plots in both years. Thus, arrowleaf clover appears to offer some potential for weed control, although arrowleaf clover probably would not be recommended exclusively for that purpose.

Percent Leaf and Crude Protein Content

The percentage of leaf (Table 3), as a percent of dry matter, declined substantially with advancing maturity from May to June. Both the highest initial values and the greatest decline in percent leaf were noted in clover from the 0 and low P treatments. Clover plants in these treatments were much smaller in size and perhaps less advanced in growth and maturity when initially sampled in May, thus having a higher leaf:stem ratio. In June, little difference was noted in percent leaf between years, although clover on the low P treatments had the highest percent leaf.

Table 3. Percent of leaf in arrowleaf clover.

Treatment	May, 1984	June, 1984	June, 1985
0 P	60.8	34.1	37.6
120 P	36.9	20.0	28.4
160 P	38.7	30.9	29.5
0 P	62.2	33.7	45.4
40 P	65.0	29.5	29.8
80 P	53.9	24.1	31.4

Crude protein in the leaf approximated or exceeded 20% crude protein in nearly all cases (Table 4). Generally, little difference was noted in crude protein of the leaf as the plant matured (May vs June) except that clover from the two highest P treatments had approximately 7% more crude protein in the leaves during May ($P<.05$). As expected, protein content in the stems declined noticeably with maturity from about 12% CP in May to 7 to 9% in June.

Considering protein content of the leaf plus stem (Table 5), arrowleaf clover harvested in May of 1984 contained approximately 17% crude protein, ranging from 16.5 to 18.1%. The lowest values were obtained on the low P and highest values on the high P treatments, reflecting the higher protein content in the leaves on the high P treatments. By June, protein in the arrowleaf clover declined to approximately 11%. In 1985, protein values in June were slightly higher than in 1984, being 13 to 14%. Perhaps the plants were less mature at harvest than in the previous year.

One useful way to assess productivity on the various clover treatments is to compare protein production per unit of land (pounds of clover X % CP/100). There was little difference in protein production between the 0 and low P treatments, but protein production was about twice as high on the 80 lb P treatment and 3 to 4 times greater on the

Table 4. Crude protein (%) in the leaves and in the stems of arrowleaf clover and in the grass from plots with no phosphorus and no clover.

	Leaf			Stem			Grass
Treatment	May-84	June-84	June-85	May-84	June-84	June-85	June-85
0 P	19.5	18.5	21.5	11.8	7.5	9.1	8.0
120 P	27.9	20.8	24.5	12.3	6.6	9.7	9.6
160 P	26.3	22.2	24.7	12.6	7.4	10.3	6.4
0 P	20.0	20.1	20.9	11.6	7.3	8.6	9.6
40 P	19.9	20.5	20.4	12.6	7.8	9.2	9.2
80 P	21.2	19.8	22.3	12.6	8.1	9.7	9.3

Table 5. Crude protein (%) contributed by the leaf and stem of arrowleaf clover.

	May, 1984			June, 1984			June, 1985		
Treatment	Leaf	Stem	Total	Leaf	Stem	Total	Leaf	Stem	Total
0	11.9	4.6	16.5	6.3	4.9	11.3	8.1	5.7	3.8
120 P	10.3	7.8	18.1	4.2	5.3	9.4	7.0	7.0	13.9
160 P	10.2	7.7	17.9	6.9	5.1	12.0	7.3	7.3	14.6
0 P	12.4	4.4	16.8	6.8	4.8	11.6	9.5	4.7	14.2
40 P	13.0	4.4	17.4	6.1	5.5	11.6	6.1	6.5	12.5
80 P	11.4	5.8	17.2	4.8	6.2	10.9	7.0	6.7	13.7

Table 6. Protein production from arrowleaf clover among various treatments.[1]

Treatment	Year 1 (1984)	Year 2 (1985)
	lb/acre	
Control	---	---
0 P	171.8	231.4
120 P	543.6	743.6
160 P	781.9	709.6
0 P	165.8	224.5
40 P	173.4	228.4
80 P	327.1	399.8

[1]Based upon June, the month in which yield data were collected.

120 and 160 lb P treatments. Similar differences were noted between treatments in 1985, although the actual values were a little greater on all treatments. This concurs with the somewhat higher protein values in 1985 (Table 6).

Arrowleaf clover can be incorporated into a native tallgrass prairie without eliminating the grass, although grass production may be decreased in drier years, and the stand can benefit from phosphorus applied at rates as high as 160 lb/acre. The presence of clover, however, did have an impact on the grass community, disrupting the plant community at the highest phosphorus rates. The surviving grasses formed scattered large bunches with considerable bare ground in between the bunches, which would not be considered a desirable grass community. At the highest phosphorus rates, perhaps an operator should be aiming for conversion to predominantly a clover pasture, while at the low and moderate rates of phosphorus, the effect of clover on the grass community was not severe. To allow clover re-establishment, pastures would need to be grazed or mowed to about a 5 inch stubble height each fall. The potential economic benefits of phosphorus application to arrowleaf clover in native range would depend upon the relative costs of phosphorus fertilizer, the value of increased forage production from arrowleaf clover, any potential value in better weed control and any decrease which may occur in grass production, especially in drier years.

Literature Cited

Westermann, R.L., et. al. 1984. Phosphorus and potassium effects on yield and nutrient uptake in arrowleaf clover. Soil Sci. 48:1292.