Effect of NPK Fertilization on Dry Matter Yield and Crude Protein Concentration of *Poa pratensis* L. Grown on Muck Soil

J. W. Lightner, C. L. Rhykerd, E. L. Hood, G. E. Van Scoyoc, and D. B. Mengel
Department of Agronomy, Purdue University, West Lafayette, Indiana 47907

There are approximately 200,000 hectacres of muck soil for agricultural use in northern Indiana. Most of these soils are used for production of corn (*Zea mays* L.) and soybeans (*Glycine max.* (L.) Merrill).

Because of problems associated with producing grain on these soils, e.g., late planting due to wet conditions, early frosts resulting from cold air drainage and excessive weed competition, some farmers are profitably utilizing these depressional soils for pasture. Kentucky bluegrass (*Poa pratensis* L.) is well adapted to muck soils but little is known about its soil fertility requirements under these conditions. Therefore, the following two-year study was initiated in the spring of 1979 on an Edwards muck soil (Limnic Medisaprist) at the Pinney-Purdue Agricultural Center in Wanatah, Indiana.

Dry matter yield and percent crude protein were determined for each of four cuttings taken during the 1979 and 1980 growing seasons. N applied at 168 kg/ha significantly increased dry matter yield by approximately 25%. Crude protein was increased 767 kg/ha when N was applied. P_2O_5 significantly increased dry matter yield by approximately 12%. K_2O had little effect on dry matter yield production. Highest yield and crude protein production were obtained on plots receiving both N and P_2O_5.

Based on the data obtained from this two year study, it appears that this shallow muck soil is capable of supplying adequate amounts of K at current yield levels. Effects of P_2O_5 were most beneficial when applied with N. However, the results indicated that N is the major fertilizer element limiting Kentucky bluegrass pasture production on an Edwards muck soil.

Introduction

Cultural problems associated with corn and soybean production on organic soils have directed researchers to grassland farming of these areas. Such areas require minimal drainage for good growth of many cool-season grasses.

Response of cool-season grasses such as Kentucky bluegrass to NPK fertilizers when grown on organic soils has been previously reported. Tesar and Shepard (11) reported dry matter production for orchardgrass, tall fescue, and smooth bromegrass was increased significantly when each was fertilized at rates of 50, 87, and 249 kg/ha of NPK respectively when grown on a well-drained Houghton muck soil. Schoper et al., (10) reported that 168 kg/ha of N significantly increased dry matter yield by 64%, and significantly increased percent crude protein in quackgrass on a soil classified as a Terric Borohemist. Schoper et al., (9) reported that P_2O_5 at 120 kg/ha in combination with N and P applications gave optimum yield increases, when compared to applications of N and K_2O without P_2O_5.

O'Toole (8), Greenan and Mulqueen (4) found that an annual application of 45-70 kg/ha of P_2O_5 is sufficient to maintain yields of an established sward on peaty soils comparable to those normally obtained on mineral soils. O'Toole (8) concluded that responses to N fertilization are greatest on pure grass swards on raw peat. Lightner et al., (5) reported that 168 kg/ha of N resulted in a 30% increase in dry matter yield and a 72% increase in total crude protein per hectare on an Edwards muck soil. Malzer et al., (6) experimenting with orchardgrass, quackgrass, and reed canarygrass on organic soils, determined that significant dry matter increases resulted when N was applied up to rates of 336 kg/ha. In addition, crude protein concentration increased as N rate increased, but higher crude protein yield resulted from split application of the N rates.

Blair et al., (1) concluded from an experiment conducted on an Edwards muck soil located in northern Indiana that a mixture of Kentucky bluegrass and birdsfoot trefoil, when utilized as a pasture for beef cattle, can be a profitable alternative to corn or soybean production. However, the Kentucky bluegrass and birdsfoot trefoil mixture must be grazed properly or the pasture will become predominantly Kentucky bluegrass.

The following two year experiment was conducted to study the response of Kentucky bluegrass to NPK fertilization. Many of these pastures can be found in the muck areas of northern Indiana and very little research has been conducted relative to the problems unique to such pastures.

Materials and Methods

In order to determine the response of Kentucky bluegrass to NPK fertilization, a two year study was conducted on the Pinney-Purdue Agricultral Center at Wanatah, Indiana. The experimental design was a randomized complete block with 8 fertilizer combinations and 3 replications. The eight fertilizer combinations, expressed as kg/ha of N, P_2O_5, and K_2O, were 0-0-0, 0-224-0, 0-0-448, 0-224-448, 168-0-0, 168-224-0, 168-0-448, and 168-224-448.

All fertilizers were applied annually as a single broadcast application in 1979 and 1980. The source of N fertilizer was ammonium nitrate in 1979 and urea in 1980. The P and K fertilizer sources were triple super phosphate and muriate of potash, respectively.

Soil test results provided by the Purdue University Soil Testing Laboratory indicated that the organic matter was 46%, the pH was 5.1, available P was 37 kg/ha and available K was 209 kg/ha.

The plots were established on a permanent Kentucky bluegrass pasture. Each plot was approximately 3.3m X 33m. Since the pasture was grazed by beef cattle, a $1.5m^2$ cage was placed randomly on each plot in order to obtain samples for yield estimate as well as a forage sample for chemical analysis.

The caged areas were harvested four times during the 1979 and the 1980 growing seasons in May, June, August and September with a Toro lawn mower equipped with a collection bag. Crude protein concentration was determined on the Kentucky bluegrass samples collected during the 1979 and 1980 growing seasons using the technique outlined by Nelson and Sommers (7) and Bremmer and Edwards (2).

Results and Discussion

The response of Kentucky bluegrass to N fertilization is shown in TABLE 1. Adding 168 kg/ha of N increased total dry matter production by 1.4 mt/ha. The major increase in dry matter production from N fertilization occurs on the first cutting. As can be seen in TABLE 1, 168 kg/ha of N had little, if any, effect on dry matter production on each successive cutting taken during the summer months when Kentucky bluegrass becomes dormant. This is possibly due to increased soil temperatures causing an increased rate of organic matter mineralization.

TABLE 1. *Effect of N fertilization on dry matter yield of Kentucky bluegrass (1979-1980).*

	Cutting				
N	1	2	3	4	Total
kg/ha	mt/ha				
0	2.1*	1.1	1.3	1.9	6.4
168	3.1	1.0	1.5	2.2	7.8**

* Avg. over P and K
** Significant at .01

The response of Kentucky bluegrass to P_2O_5 fertilizer is presented in TABLE 2. An annual application of 224 kg/ha of P_2O_5 significantly increased total dry matter production 0.7 mt/ha ($P < .01$). The main effect of K_2O fertilizer is shown in TABLE 3. K_2O had no significant effect on dry matter production on this muck soil.

The effect of N fertilization on crude protein production in Kentucky bluegrass forage is shown in TABLE 4: Application of 168 kg/ha of N increased total crude protein 64% (768 kg/ha) over treatments receiving no N. Raising N levels to 168 kg/ha increased overall crude protein concentrations from 17.7 to 22.9% (TABLE 5). Crude protein concentration was greatest early in the growing season and declined with each successive cutting. This decline in crude protein concentration is probably due to increasing levels of solar radiation and air temperatures which affect the vegetative growth habits of Kentucky bluegrass. Similar data for Kentucky bluegrass have been reported by Hojjati et al., (3) although their experiment was conducted on a mineral soil. Schoper et al., (10) also reported similar trends in quackgrass grown on organic soil when treated with N fertilizer. They also reported that crude protein levels were generally higher in forage receiving split applications of N on the second, third and fourth cuttings.

Maximum dry matter yields, averaged over both years, occurred on N-P_2O_5 treated plots. It appeared that the P_2O_5 acted synergistically with N, resulting in

TABLE 2. *Effect of P_2O_5 fertilization on dry matter yield of Kentucky bluegrass (1979-1980).*

	Cutting				
P_2O_5	1	2	3	4	Total
kg/ha	mt/ha				
0	2.5*	1.0	1.3	1.9	6.7
224	2.7	1.1	1.4	2.2	7.4**

* Avg. over N and K
** Significant at .01

TABLE 3. *Effect of K_2O fertilization on dry matter yield of Kentucky bluegrass (1979-1980).*

	Cutting				
K_2O	1	2	3	4	Total
kg/ha	mt/ha				
0	2.5*	1.1	1.4	2.0	7.0
448	2.7	1.0	1.4	2.1	7.2 (N.S.)

* Avg. over N and P

TABLE 4. *Effect of N fertilization on crude protein production of Kentucky bluegrass (1979-1980).*

N	TOTAL
hg/ka	
0	1206*
168	1974**

* Avg. over P and K
** Significant at P < .01

TABLE 5. *Effect of N fertilization on crude protein concentration in Kentucky bluegrass (1979-1980).*

	Cutting				
N	1	2	3	4	Avg.
kg/ha	%				
0	17.7*	17.6	18.1	17.4	17.7
168	25.4	23.5	21.3	21.5	22.9**

* Avg. over P and K
** Significant at .01

increased forage dry matter yield. Conversely, on N-K_2O treated plots the additional potassium inhibited the N response, thus, resulting in decreased forage yields.

The results of this two year study indicate that N is the major limiting fertilizer element at current yield levels. However, applications of P also resulted in significant yield increases. No significant effect can be attributed to K applications. Nitrogen fertilizer, at the rate of 168 kg/ha, increased crude protein production an annual average of 767.4 kg/ha. When considering the problems associated with grain crop production on organic soils, improved pasture management along with proper fertilization may be a feasible alternative on these soils.

Literature Cited

1. BLAIR, B. O., C. L. RHYKERD, R. E. MULLER, W. O. JONES and J. J. VORST. 1977. Ecological adaptation of certain forage species on shallow muck soils. Proc. Ind. Acad. Sci. 86:217-225.
2. BREMMER J. M. and A. P. EDWARDS. 1965. Determination and isotope-ratio analysis of different forms of nitrogen in soils. I. Apparatus and procedure for distillation and determination of ammonium. Soil Sci. Amer. Proc. 29:504-507.
3. HOJJATI, S. M., W. C. TEMPLETON, JR., and T. H. TAYLOR. 1977. Changes in chemical composition of Kentucky bluegrass, and tall fescue herbage following N fertilization. Agron. J. 69:264-269.
4. GREENAN, E. and J. MULQUEEN. 1965. Grass production on blanket peat: I. Phosphorus requirements. Ir. J. Agric. Res. 3(1):37-49.
5. LIGHTNER, J. W., C. L. RHYKERD, B. O. BLAIR and B. J. HANKINS, V. L. LECHTENBERG and J. M. HERTEL. 1979. Response of *Poa pratensis* L. to NPK on shallow muck soil. Proc. Inc. Acad. Sci. 89:400-403.
6. MALZER, G. L., R. P. SCHOPER and J. LENSING. 1976. Influence of nitrogen rate and timing of application on the production and quality of forage grasses on organic soils. Soil Ser. Minn. Univ. Agric. Ext. Serv. 97:162-166.
7. NELSON, D. W. and L. E. SOMMERS. 1973. Determination of total nitrogen in plant material. Agron. J. 65:109.
8. O'TOOLE, M. A. 1970. Grass production on peat soils. J. Br. Grassld. Soc. 25:131-135.

9. SCHOPER, R. P., C. SIMKINS, G. MALZER and R. FARNHAM. 1975. Fertilization of grasslands on organic soils. Soil Ser. Dep. Soil Sci. Univ. Minn. 95:189-206.
10. SCHOPER, R. P., G. L. MALZER and C. A. SIMKINS. 1979. Influence of N and P on the yield and chemical composition of quackgrass growing on an organic soil. Agron. J. 71(6):1034-1037.
11. TESAR, M. B. and L. N. SHEPARD. 1963. Evaluation of forage species on organic soils. Agron. J. 55:131-134.