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Alfalfa Response to Varying Rates of Phosphorus and Potassium Fertilization on Deep, Red, Limestone - Derived Soils of the Pennyroyal Area In Kentucky

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ALFALFA RESPONSE TO VARYING RATES OF PHOSPHORUS AND POTASSIUM FERTILIZATION ON DEEP, RED, LIMESTONE - DERIVED SOILS OF THE PENNYROYAL AREA IN KENTUCKY.

by

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The Western Pennyroyal area of Kentucky consists largely of deep, well-drained limestone-derived soils occurring on an undulating to rolling landscape. A thin loess mantle overlies the limestone residuum in many areas. Soils on these landscapes are capable of good crop production, providing the basis of the rather intensive grain-hay-tobacco-livestock farming systems common to the Pennyroyal area. Because of the well-suited physical characteristics of these soils, alfalfa is a very important hay crop to this area.

In recent years, there has been some concern about fertilizer recommendations for growing alfalfa on these deep, red soils. Because of this, we set up a field experiment to test the crop response to fertilizer recommendations made by UK agronomists for growing alfalfa.

Procedure

A site was selected in Warren County, Kentucky, on the farm of Mr. Phillip Simon. The field contained a one-year old stand of alfalfa (var. Buffalo) and orchardgrass. The soil was Pembroke silt loam testing pH 7.0; P (Bray No. 1) 55 pp2m; K (neutral N NH_4OAc) 240 pp2m. Based on this soil test, a recommendation of 90 lbs P_2O_5, 100 lbs K_2O, and 2 lbs B per acre per year for a 5-ton alfalfa yield was made. A fertility study was designed to test phosphorus and potassium rates at 0, 1, 1.5, and 2 times the recommended rate. These treatments (0, 90, 135, and 180 lbs/A P_2O_5 and 0, 100, 150, and 200 lbs/A K_2O per year) were laid out in a completely randomized block design with 3 replications. All phosphate test plots were uniformly treated with 200 lbs K_2O/A/yr; all potash test plots uniformly received 180 lbs P_2O_5/A/yr; and all test plots received 2 lbs B/A/yr. All fertilizer was topdressed in late March or early April of each year. Soil samples were taken to a 36-inch depth in 6-inch increments before and after the experiment, with some 0-6 inch samples being taken during the study. Plots were harvested on a rigid clipping schedule, beginning with first harvest at early bloom, and three subsequent harvests were made on 5-week intervals. An aftermath harvest was made after growth stopped, usually in early November (Table 1). Plots were harvested with a sickle-bar mower, with grab samples being taken for determination of moisture and mineral content, and nutritive value index (NVI)[1/]. The study began in 1970 and was conducted for 6 years.

Table 1. CUTTING SCHEDULE FOLLOWED (6-YR AV)

Cutting	Average Cutting Date	Average Days between Harvests	Pounds Dry Matter Per Cut (Av. of all treatments)
1	May 10	-	2,638
2	June 17	38	2,989
3	July 23	36	2,386
4	Sept. 1	39	2,191
5	Nov. 8	68	801

Yield Results

High yields were obtained over the six year period (Tables 2-3). These were nearly twice Kentucky's state average yield of approximately three tons per acre. Our experience leads us to believe such prolonged yield levels are due in large part to four factors: (1) A good initial stand, and maintenance of that stand; (2) growing season moisture; (3) adequate supplies of nutrients in the soil; and (4) a rigid cutting management started in early May and maintained on a five week schedule thru the summer, with a longer period of regrowth allowed for buildup of carbohydrate root reserves prior to cold weather in the fall. As shown (Table 1) there was very uniform distribution of total yield among the first four cuttings with this cutting schedule. This contrasts to less rigid cutting schedules which often produce two-thirds to three-fourths of the total yield in the first two cuttings.

With the exception of K rates in 1973, applied rates of P and K did not increase yields over unfertilized plots at the five percent probability level. However, there was a strong trend for the first applied rate of P and K to increase yields --- more so for P than K. The higher applied rates rarely gave further yield increases and in some years decreased them. The reason for such decreases is unknown.

1/ N.V.I., or nutritive value index, is an empirical laboratory evaluation of forage nutritive value which has been correlated with animal performance.

Table 2. EFFECT OF PHOSPHATE RATES ON DRY MATTER (LBS/A) REMOVAL

Year	LBS P_2O_5/A/YR 0	90	135	180	L.S.D. (.05)
1970	9541	10004	10132	10172	N.S.
1971	11673	12623	11670	12546	N.S.
1972	8696	9824	9448	9304	N.S.
1973	11313	12990	11865	12690	N.S.
1974	10759	11786	11547	11087	N.S.
1975	7669	8629	8434	8043	N.S.
AV.	9942	10976	10516	10640	N.S.

Table 3. EFFECT OF POTASH RATES ON DRY MATTER (LBS/A) REMOVAL

Year	LBS K_2O/A/YR 0	100	150	200	L.S.D. (.05)
1970	10714	10167	9772	10284	N.S.
1971	12686	13153	13155	12735	N.S.
1972	9341	10198	9861	9186	N.S.
1973	11747	12183	13245	11805	983
1974	11192	12005	12145	11832	N.S.
1975	8451	9135	10373	8902	N.S.
AV.	10688	11140	11425	10791	N.S.

Effect of Fertilizer Rates on Phosphate and Potash Removal

Amounts of phosphate and potash removed in dry matter tended to increase as rate applied was increased (Tables 4-5). Even without additions of fertilizer, yields and removal rates of phosphate and potash were high, indicating (1) a long-term effect of the initial level of P and K availability; (2) a high P and K supplying capacity in this soil; or (3) a combination of both.

Table 4. EFFECT OF PHOSPHATE RATES ON ALFALFA PRODUCTION AND PHOSPHATE REMOVAL ON A PEMBROKE SOIL

Pounds P_2O_5 Used		Tons Hay Removed*		Pounds P_2O_5 Removed	
Per Year	6-Yr. Total	Av. Per Yr.	6-Yr. Total	Av. Per Yr.	6-Yr. Total
0	0	5.65	33.9	64	385
90	540	6.23	37.4	82	495
135	810	5.98	35.9	82	495
180	1080	6.05	36.3	85	508

* Hay @ 88% Dry Matter

Table 5. EFFECT OF POTASH RATES ON ALFALFA PRODUCTION AND POTASH REMOVAL ON A PEMBROKE SOIL.

Pounds K_2O Used		Tons Hay Removed*		Pounds K_2O Removed	
Per Year	6-Yr. Total	Av. Per Yr.	6-Yr. Total	Av. Per Yr.	6-Yr. Total
0	0	6.07	36.4	318	1908
100	600	6.33	38.0	368	2208
150	900	6.48	38.9	379	2275
200	1200	6.13	36.8	382	2292

* Hay @ 88% Dry Matter

Effect of P - K Rates and Removal on Soil Test Levels

Effects of P - K rates on P-K soil test levels as shown in Figures 1-2 and Tables 6-7 show there was little influence of K rates on subsoil content of K. However, the 200 K_2O/A/Yr rate did result in higher soil test readings in the 0-12 inch soil depth. The high (200 lb K_2O/A/Yr) rate supplied 1200 lbs K_2O during the 6 years, with plant removal of 2290 lbs K_2O during that time. During the same period, soil test level was increased from 240 to 363. With no potash applied, plant removal was about 1900 pounds of potash during the 6 years, with the soil test level dropping to 145. The two highest rates of P_2O_5 applied also resulted in large increases of soil test P levels in the 0-3 inch layer and somewhat lesser increases in the 6-18 inch depth. The two highest rates of P_2O_5 applied were considerably in excess of crop removal (Table 4).

Table 6. CHANGES IN SOIL TEST P LEVELS IN THE SURFACE 6-INCHES OF A PEMBROKE SOIL BEFORE, DURING AND AFTER 6-YEARS ALFALFA PRODUCTION.

P_2O_5	pp2m Soil Test Levels of P in Surface Soil (0-6 inches)				
	Before Study	During Study			After Study
(lbs/A/Yr)	March 1970	March 1974	Nov. 1974	March 1975	March 1976
0	55	34	32	38	21
90	55	72	93	76	97
135	55	--	--	--	145
180	55	--	--	--	155

Table 7. CHANGES IN SOIL TEST K LEVELS IN THE SURFACE 6-INCHES OF A PEMBROKE SOIL BEFORE, DURING, AND AFTER 6-YEARS ALFALFA PRODUCTION.

K_2O	pp2m Soil Test Levels of K In Surface Soil (0-6 inches)					
	Before Study	During Study				After Study
(lbs/A/Yr)	March 1970	March 1973	March 1974	Nov. 1974	March 1975	March 1976
0	240	177	172	108	99	145
100	240	200	199	117	129	195
150	240	232	---	---	---	260
200	240	228	---	---	---	363

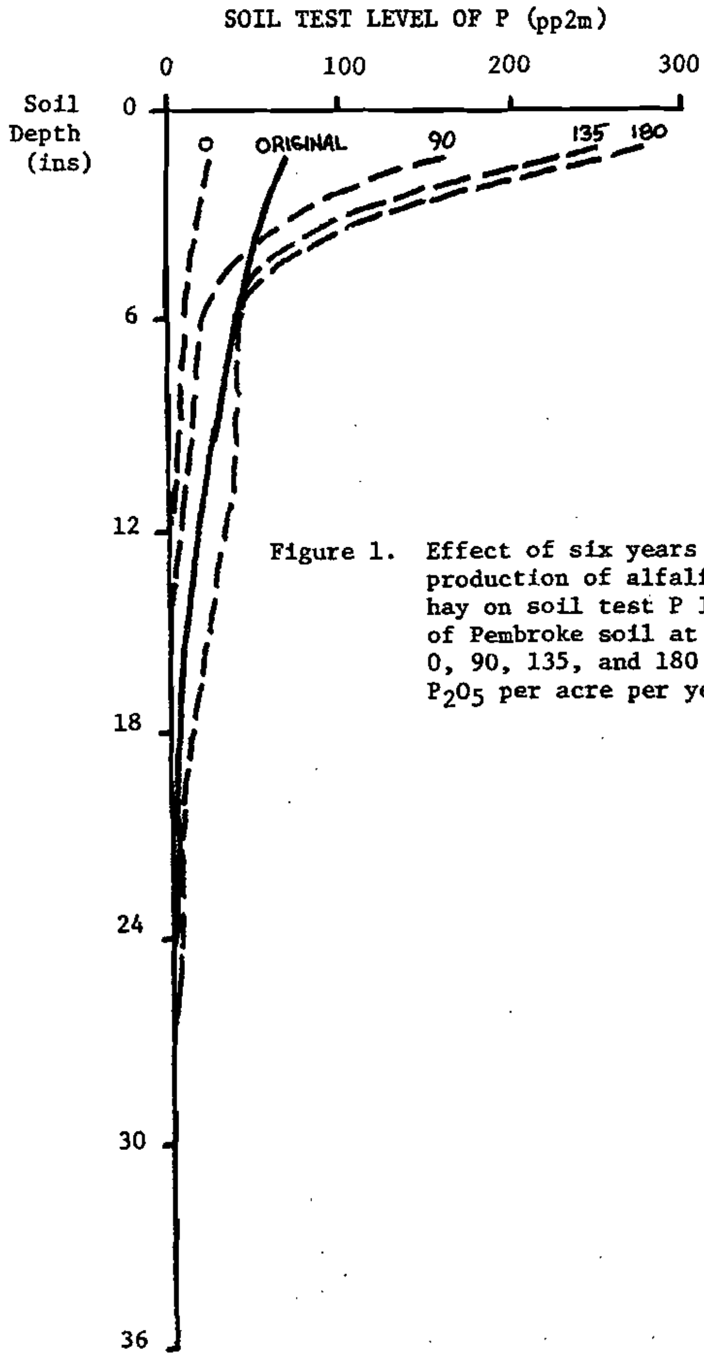

Figure 1. Effect of six years production of alfalfa hay on soil test P levels of Pembroke soil at 0, 90, 135, and 180 lbs P_2O_5 per acre per year.

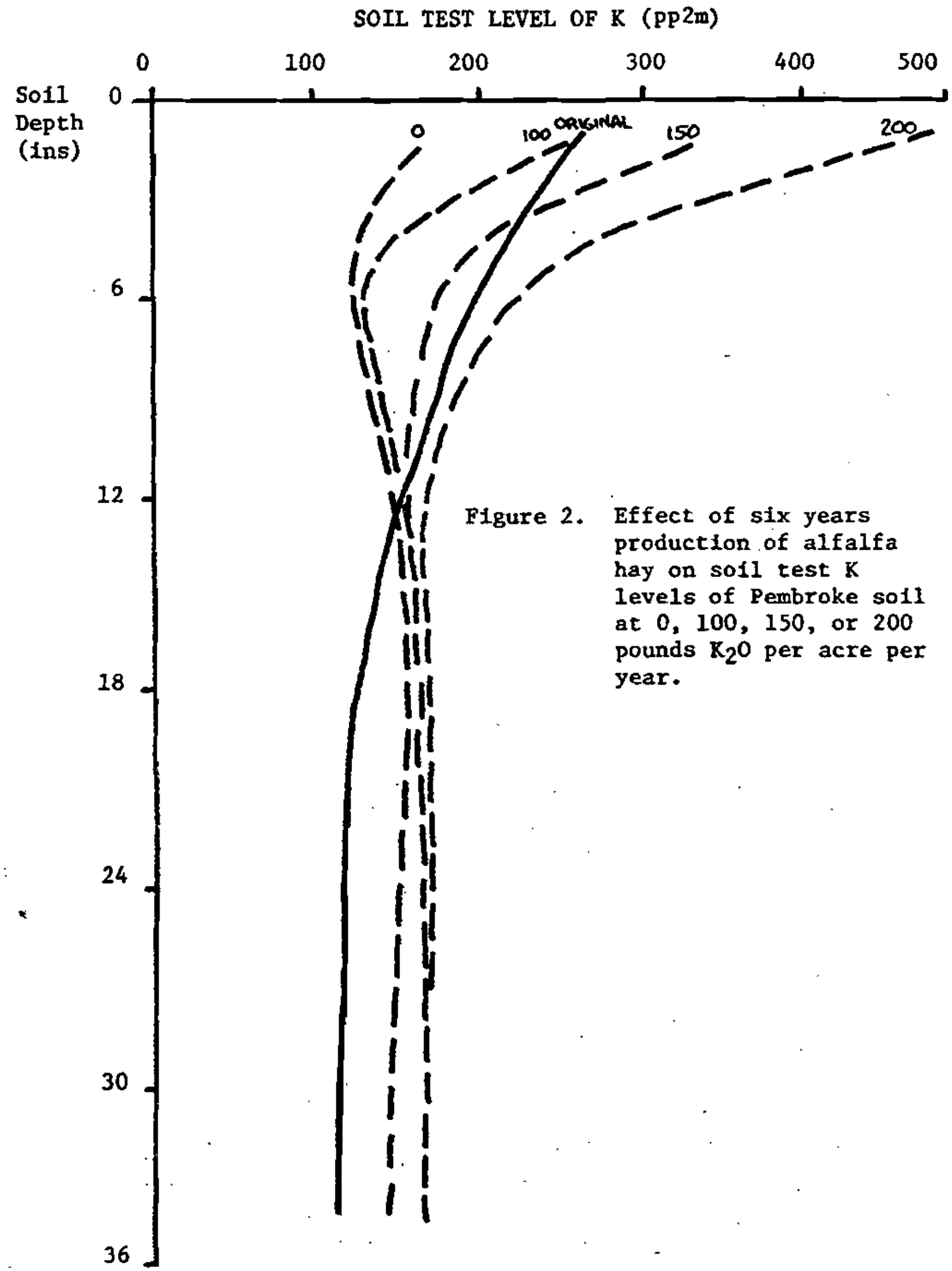

Figure 2. Effect of six years production of alfalfa hay on soil test K levels of Pembroke soil at 0, 100, 150, or 200 pounds K_2O per acre per year.

Dry Matter Production, Mineral Removal, and Quality (6-Yr Av)

As shown in Tables 8-9 there was little difference ($p = 0.05$) among the treatments tested for their effect on dry matter production, content of P, K, Ca, Mg and feed quality (N.V.I.). The recommended rate of phosphate (90 lb/A/Yr) did result in a greater removal of P than the check (0) plot, but no more so than the higher rates. Magnesium removal at the 90 lb/A/Yr P_2O_5 rate was also greater than the check plot. Although not shown to be significantly different ($p = .05$), the 90 lb P_2O_5 rate consistently yielded higher than the check plot both within years and among years.

With the exception of greater potash removal from the potash treated plots, the potash rates tested also had no statistically significant effect ($p = .05$) on yield, mineral removal, and quality of hay. But as with phosphate, the 100 pound K_2O/A/Yr rate consistently yielded higher than the check plot within and among years.

Quality (N.V.I.) is closely correlated to animal intake and performance. According to Donefer, et al. (1966) good alfalfa has an N.V.I. of approximately 70. All our N.V.I. values are very close to 70 indicating that alfalfa-orchardgrass harvested for hay at bud to early bloom at first harvest and then cut at five week intervals will result in a high quality hay.

Table 8. EFFECT OF RATES OF PHOSPHATE ON DRY MATTER PRODUCTION, UPTAKE OF P, K, CA, MG AND N.V.I.[1/] BY ALFALFA GROWN ON PEMBROKE SOIL.

P_2O_5	Annual Removal (lbs/A/Yr)-6 Yr. Av.					
(lbs/A/Yr)	Dry Matter	P	K	Ca	Mg	N.V.I.
0	9942	28	240	105	28	67.2
90	10976	36	290	120	31	68.6
135	10516	36	288	115	31	68.6
180	10640	37	272	114	31	67.4
L.S.D. (.05)	N.S.	6	N.S.	N.S.	2	N.S.

1/ Nutritive Value Index

Table 9. EFFECT OF RATES OF POTASH ON DRY MATTER PRODUCTION, UPTAKE OF P, K, CA, MG, AND N.V.I.[1/] BY ALFALFA GROWN ON PEMBROKE SOIL.

K_2O	Removal (lbs/A/Yr)-6 Yr.Av.					
(lbs/A/Yr)	Dry Matter	P	K	Ca	Mg	N.V.I.
0	10688	37	265	129	31	70.0
100	11140	37	307	130	30	69.4
150	11425	37	316	128	30	69.4
200	10791	35	318	126	28	70.7
L.S.D. (.05)	N.S.	N.S.	28	N.S.	N.S.	N.S.

1/ Nutritive Value Index

CONCLUSIONS

1. High yields of alfalfa hay are possible on deep, red soils of the Kentucky Pennyroyal which are fertilized to high medium (50-60 Bray 1 soil test extractable P or 225-250 neutral N NH_4OAc extractable K) fertility levels and the first harvest is made in early May and subsequent cuttings made on five week intervals, with adequate time for building up root reserves in the fall.

2. The recommended rates of P_2O_5 and K_2O based on initial soil test (90 P_2O_5 and 100 K_2O) for a five ton yield goal were sufficient for obtaining the higher (but statistically non-significant) yield increase over the check and yet maintaining residual soil test levels. Even though such increases were not significant at the five percent probability level, they were consistently higher than check yields. Soil test levels of both P and K dropped to below original levels on check plots after six years where no additional P or K had been applied. The 90 P_2O_5 and 100 K_2O annual fertility rate increased the P level in soil from 55 at the beginning of the study to 95 at the end while K levels dropped slightly (from 240 to 195) at the end of the study.

   Results of this study on a deep, red soil (Pembroke) of the Pennyroyal already at a good level of fertility (nearly high for both P and K) show no need for higher rates of P and K than those currently being recommended in order to obtain high yields over a period of 6 years.

ACKNOWLEDGEMENTS

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