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Phosphorus and Potassium Fertilization of Irrigated Alfalfa

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Alfalfa is a high yielding, irrigated crop when properly managed on the sandy soils of south central Kansas. Good management includes providing optimum amounts of plant nutrients, such as phosphorus and potassium. Alfalfa hay removes approximately 12 pounds of phosphate (P_2O_5) and 60 pounds of potash (K_2O) in each ton.

Methods of supplying phosphorus and potassium include large preplant applications, annual applications, or a combination of preplant and annual applications. This research was conducted to evaluate phosphorus and potassium rates and phosphorus application frequencies for their effect on alfalfa forage yields and resulting soil test levels.

Procedure

In the fall of 1975, a large alfalfa management study was started at the Sandyland Experiment Field near St. John, Kansas, including varieties, fertility levels, and cutting managements. The stand of the variety 'Kanza' has been maintained since the start of the experiment and results for the fertility treatments with this variety are used to evaluate long-term fertility effects on forage yield and available phosphorus and exchangeable potassium soil test levels.

Preplant fertility treatments applied in the fall of 1975 consisted of phosphorus rates of 0 and 320 pounds per acre of phosphate (P_2O_5) and imposed on

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top of the preplant treatments were annual phosphate treatments of 0, 40, 80, and 120 pounds P_2O_5 per acre started in the spring of 1977. The phosphorus was applied as concentrated superphosphate (0-46-0). All phosphate treatments received an annual 80-pound-per-acre potash (K_2O) application. Potassium treatments of 0, 80, and 160 pounds K_2O per acre also were included as annual broadcast applications with a uniform phosphorus application of 120 pounds P_2O_5 per acre. In 1981, two higher potassium rates (320 and 640 pounds K_2O per acre) were established on plots that had been receiving 80 pounds K_2O per acre and phosphorus applications of 120 pounds P_2O_5 per acre.

Four to six harvests have been taken each year since 1977, depending on growth stage and weather, and reported as tons of forage per acre at 15 percent moisture. Yearly soil samples (0 to 6" depth) were collected on each treatment in the spring just prior to the annual fertilizer applications.

Results

Annual Phosphorus Effects. A significant yield response to phosphorus application has been obtained each year on this initially low phosphorus-soil-test soil (18 lb/A, Bray and Kurtz—1 extraction) as seen in Table 1. Where no preplant phosphorus application was made, the optimum phosphorus rate increased from about 40 pounds P_2O_5 per acre for 1977 to near 120 pounds per acre by 1981. With top yields in most years of near 10 tons per acre and a phosphate removal of about 12 pounds of P_2O_5 per ton, this increase in the later years of the study is not surprising for this sandy soil.

Phosphorus soil test results show that only 120 pounds P_2O_5 per acre applied annually increased soil phosphorus over the initial amount (Figure 1). No phosphorus application and 40 pounds P_2O_5 applied annually resulted in drawdown from the original soil test of 18 pounds phosphorus per acre to 8 to 12 pounds phosphorus per acre during the last three to four years of the study. The annual application of 80 pounds P_2O_5 per acre has caused a slow decline in the available phosphorus.

Preplant Phosphorus. The preplant application of 320 pounds per acre P_2O_5 without additional annual phosphorus application increased yields over the no fertilizer treatment and yielded as well as the annual 40 pounds per acre P_2O_5 without preplant phosphorus for all seven years of the study (Table 1). This reflects a good residual effect from the preplant phosphorus. However, yields for the preplant phosphorus alone

Table 1. Effect of Phosphorus Fertilization on Alfalfa Yield

Pounds P_2O_5/Acre		Alfalfa Yield, Tons/Acre						
Preplant	Annual	1977	1978	1979	1980	1981	1982	1983
0	0	8.1	7.7	7.4	7.1	9.1	8.2	5.0
0	40	9.3	9.3	8.9	8.5	10.6	9.7	6.0
0	80	9.3	9.7	9.5	8.8	11.4	10.4	6.6
0	120	9.6	10.6	10.0	9.5	12.1	11.4	7.3
320	0	9.4	9.9	9.0	8.3	10.1	9.4	5.8
320	40	9.9	10.7	9.7	9.1	11.4	10.2	6.2
320	80	9.5	10.3	9.7	9.2	12.1	11.2	6.7
320	120	9.8	10.6	9.6	9.5	11.9	11.1	7.0
LSD .05		0.5	0.6	0.6	0.7	0.8	0.7	0.6

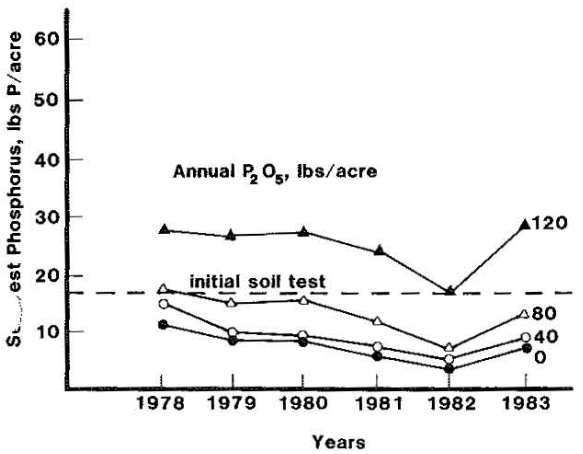

Figure 1. Alfalfa management soil test of available phosphorus: annual applications of P_2O_5.

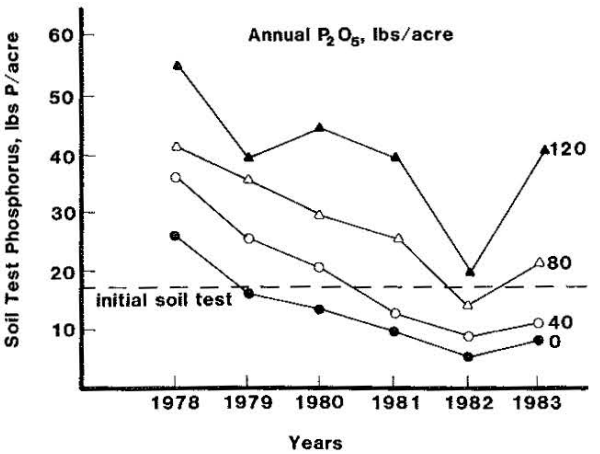

Figure 2. Alfalfa management soil test available phospnorus: preplant application of 320 pounds of P_2O_5 plus annual applications.

treatment were significantly less than those for the higher annual application in the later years of the study. Preplant phosphorus application with annual 40 pounds per acre P_2O_5 application showed an advantage over the annual 40 pound per acre P_2O_5 without preplant application in four of the first five years. There was no consistent advantage to the 320 pound per acre P_2O_5 preplant application with annual 80 and 120 pound per acre rates over no preplant application.

The data show that optimum yields can be obtained with annual applications of phosphorus or by the combination of preplant and annual application. A heavy preplant phosphorus application will carry alfalfa for several years, but under high yield conditions will need to be supplemented by annual applications.

The phosphorus soil test results for the 320 pound per acre P_2O_5 preplant treatment mirror the yield response data (Figure 2). The preplant application of phosphorus increased the soil test in 1978 over the initial 18 pound per acre test taken prior to establishment in 1975. Over the seven year period starting in 1978, the soil tests at all annual phosphorus rates declined. Treatments with 0 and 40 pound per acre annual P_2O_5 rates declined below the initial soil test level and reached a level by 1982 similar to that of the annual phosphorus treatments without preplant phosphorus. The 80 and 120 pounds per acre P_2O_5 treatments showed a much slower decline and were not below the initial soil level by 1983.

Potassium Rates. Potassium fertilization did not result in a significant yield increase until 1983 and then only the 80 pound K_2O per acre rate was significantly higher yielding than the control (Table 2). This lack of potassium response is somewhat surprising, since po-

Table 2. Effect of Annual Potassium Fertilization on Alfalfa Yield

Pounds K_2O/Acre	Alfalfa Yield, Tons/Acre						
	1977*	1978*	1979*	1980*	1981	1982	1983
0	9.6	10.5	9.6	9.6	11.9	11.5	6.6
80	9.6	10.6	10.0	9.5	12.1	11.4	7.3
160	10.0	10.6	9.6	9.5	11.9	10.9	6.8
320	—	—	—	—	12.0	10.9	6.9
640	—	—	—	—	11.6	10.9	7.1
LSD .05	NS	NS	NS	NS	NS	NS	0.6

*No 320 and 640 pound treatments.

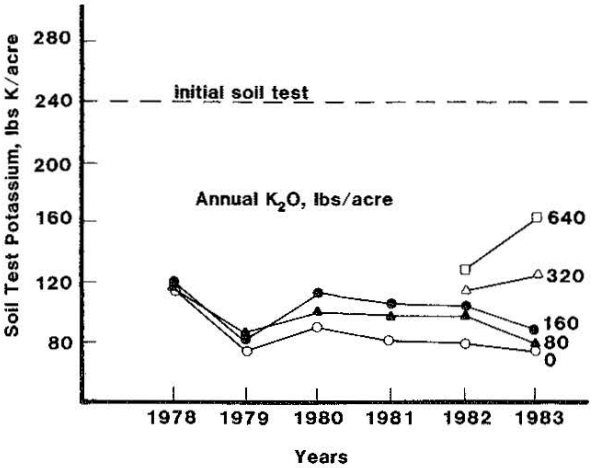

Figure 3. Alfalfa management soil test levels of potassium.

tassium removal by alfalfa is high (about 60 pounds of K_2O per ton) and the initial exchangeable potassium soil test level was 242 pounds potassium per acre. The inclusion of the higher potassium rates since 1981 to try to compensate for removal has not resulted in increased yields.

Potassium soil test levels decreased by 1978 to roughly 120 pounds per acre for all three potassium rates (0, 80, and 160 pounds K_2O per acre) and the potassium soil test levels for these treatments have remained in the range of 80 to 120 pounds potassium per acre for the duration of the study (Figure 3). The 320 and 640 pounds K_2O per acre treatments added in 1981 have shown a gradual increase in exchangeable potassium in 1982 and 1983, with a greater increase for the 640 than for the 320 pounds K_2O per acre. These results would suggest that potassium is being supplied to the alfalfa crop by source(s) not accounted for in the soil test measurements.

Conclusions

Alfalfa shows a yield response to phosphorus whether it is supplied as an annual or a large preplant application. Annual application of 120 pounds of P_2O_5 per acre resulted in yields equal to or greater than all other levels of P_2O_5 application, while maintaining available phosphorus soil test levels over the duration of the study. Annual applications of 80 pounds of P_2O_5 have, in most years, equalled the 120 pound rate, although soil tests have been slowly decreasing. Large preplant applications of P_2O_5 increased yield compared to no fertilizer, but yields declined with time where adequate topdress phosphorus was not applied. Productive stands of alfalfa will soon deplete even large preplant applications of P_2O_5, shortening stand life. Annual applications can provide phosphorus however long the stand is maintained.

Potassium fertilization has not resulted in any consistent yield response on the sandy soils, even when soil tests show declining levels of exchangeable potassium. This indicates that large amounts of native potassium are available for plant needs during the growing season.

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Keeping Up With Research 83 December 1984