The Effect of Phosphate Fertilization on Yield and Protein Content of Alfalfa

The response of alfalfa to phosphate fertilization was not entirely as expected. Initial soil tests indicated readily available phosphorous (NH_4F —HCL extraction) to be at a 5 pound per acre level which is normally considered very low (especially for alfalfa produccion). A highly significant yield increase was expected but this was not the case.

Table 3 shows the effect of P_{205}, con alfalfa yields at varions levels of K_20 and lime.

Table 3. — Total Yield - dry matter (lbs/acre)
(Total of three cutings*)

Pounds K_20 per acre	Pounds $P_2 0_5$ per acre applied 0	40	80
0	2335 a	2774 b	2871 b
	3441 c	3467 c	3433 c
40		2874 b	3388 c
		3649 d	3524 c
80		3638 d	3600 d
		4225 c	4825 f

Figures followed by the same letters are not significantly different at the 5 percent level based on Duncan's multiple range test.

Key: Numbers not underlined — unlimed l
Numbers underlined limed.

Plots receiving only P_{205} showed a significant increase to the first 40 pounds of P_{205} but no significant increase was obtained by an additional 40 pounds. Limed plots showed no significant increases to added P_{205} in the absence of K_20. At the 40 pound level of K_20, and in the absence of lime, a significant increase was obtained by increasing P_{205} to 80 pounds per acre. At the 40 pound per acre K_20 level, as was the case at the 0 level of K_20, those plots receiving lime did not show a significant yield increase to added P_{205}

At the highest level of K_20, no significant increases resulted from increasing P_{205} to 80 pounds per acre on unlimed plots. However, on the limed plots and at the 80 pounds per acre K_20 rate, a significant increase in yields was obtained by increasing P_{205} from 40 to 80 pounds per acre.

* Average of four replicates

Significant increases in the crude protein content of alfalfa were not obtained by increasing P_2O_5 fertilization. However, on a total crude protein per acre basis, the application of 40 pounds P_2O_5 resulted in a significant increase (table 2). Adding an additional 40 pounds of P_2O_5 had no significant effect on crude protein percent or total crude protein production.

The Effect of Potash Fertilization on Yield and Protein Content of Alfalfa

A soil test of the experimental soil showed the level of available potassium to be 480 pounds per acre. Levels in this range are generally considered adequate for alfalfa production. Consequently, a response to K_2O was expected to be of a minor nature to the response to P_2O_5 However, an analysis of tables 1 and 3 show consistently good responses to K_2O on both the limed and on the unlimed soils.

On the unlimed plots with P_2O_5 at 40 pounds per acre, no significantt increase in yields resulted from the addition of 40 pounds of K_2O per acre. An additional 40 pounds of K_2O did, however, increase yields by 27 percent. At the higher P_2O_5 rate (80 pounds per acre) significant yield increases were observed for both the 40 and for the 80 pounds K_2O per acre levels. In this case the yield increase for the initial 40 pounds K_2O was greater than for the second 40 pounds of K_2O, (18 percent increase vs 6 percent).

Significant yield increases were observed for both the 40 and 80 pounds per acre K_2O rates on the limed plots which had P_2O_5 at the 40 pounds per acre rate. At the 80 pounds per acre P_2O_5 level, the initial 40 pounds K_2O produced no significant difference in yields. The 80 pounds per acre K_2O rate did, however, produce a significant yield increase of 37 percent.

As was the case with phosphate, the application of potash had no significant effect on crude protein percentage at the 5 percent level. A significant increase was observed for total crude protein on a pounds per acre basis due to the positive effect of potash on yields.

Conclusion

The results of this experiment, although based on a total of only three cuttings, tend to confirm the results of other experiments with respect to lime, but differ somewhat from published results on phosphate and potash fertilization in the light of the soil tests taken prior to the beginning of the experiment.

There may be several reason for this variation from "normal" results. Attention must first be focused on the soil tests. Were the soil samples properly taken? If so, was the chemical analyses of the samples properly run and interpreted? An affirmative answer to the first two question brings up a third. Do chemical analyses of the soil accurately reflect the status of various nutrients as they exist in a soil-plant relationship? I think not. A soil sample analysis is at best only a rough indicator of what nutrients, and their amounts, are extracted by a given extractant and may not always agree with the amount available to different plant species.

Soil tests alone cannot be relied upon to state the exact amounts of nutrients needed for efficient plant growth. Rather they must be used as a tool together with actual field experimentation to determine what nutrients are needed, and in what amounts, for optimum yields. This then is the purpose of this experiment and the light in which the results are interpreted.

Lime

As is the case with most tropical and sub-tropical soils, those in the Zamorano Valley are acid in nature (pH 5.5) and the addition of lime is considered necessary for the propagation of such lime loving plants as alfalfa. Significant increases in yields and in protein content were observed for lime on alfalfa grown in the Zamorano Valley. It appears from the experimental results that a minimum of 2.25 tons of lime ($CaCO_3$) should be applied to Zamorano soils for efficient production of alfalfa in that region.

The effect of lime on the protein content of alfalfa in Zamorano is of particular importance in view of the lack of high protein forages in a traditional investock producing region. The production of commercial quantities of high protein alfalfa in this area would have a marked effect on the local economy for several reasons: (1) More efficient livestock production, (2) decreased drain on the economic capital, some which is now used to import alfalfa meal, and (3) increased productivity of the soil due to the incorporation of sorely needed nitrogen and organic matter.

Phosphorus

Soils tests indicated that readily available phosphorus was extremely low in Zamorano soils (5 pounds per acre) and consequently, highly significant yield increases were expected upon fertilization with phosphorus. This was no the case.

The addition of phosphorus in the absence of lime did not produce highly significant yield increases. Small, though significant, yield increases did result from the initial 40 pounds of $P_{2}0_{5}$ in the absence of lime on the last two cuttings (table 4). On the first cuttings, yield reductions resulted from the addition of $P_{2}0_{5}$ to some fertilizer treatments. Whether this was a result of phosphorus interfering with plant nutrition and the uptake of other necessary elements or experimental error remains to be worked out in further experiments with phosphorus an alfalfa.

With lime and the 80 pounds per acre application rate of K_20. significant yield increases were observed when $P_{2}0_{5}$ was increased

Table 4. — Individual cuttings yield - dry matter (Pounds per acre)

Pounds applied K_2O per acre	Pounds applied P_2O_5 per acre: 0	40	80
		FIRST CUTTING	
0	960 a	376 b	837 b
	1186 d	1203 c	927 a
40		875 b	1115 d
		1107 d	953 a
80		1201 c	1039 d
		1553 c	1624 c
		SECOND CUTTING	
0	652 a	942 b	1031 b
	1058 b	1017 b	1220 c
40		942 b	1044 b
		1218 c	1257 d
80		1115 c	1204 c
		1294 d	1496 e
		THIRD CUTTING	
0	723 a	956 b	1011 b
	1197 c	1247 c	1286 c
40		1057 b	1229 c
		1324 d	1314 d
80		1322 d	1357 d
		1378 d	1705 e

Figures followed by the same letters are not significantly different at the 5.0 percent level based on Duncan's multiple range test.

Key: Numbers not underlined — unlimed
Numbers *underlined* — limed

from 40 to 80 pounds per acre at the last two cuttings (table 4.) It appears that adequate amounts of K_2O must be applied before the plant is able to utilize the added P_2O_5

Further investigation on phosphate fertilization should be made. Why yields do not show a response to phosphate fertilization in the light of such a low P soil test value must be examined. Does the added phosphate become tied up in the soil and become inmmediately unavailable to plants or does it in some way interfere with plant uptake of other essential elements which are even more critical in Zamorano soils? These questions, and certainly questions on micronutrients need answers.

Potassium

Potassium has a highly important role to play in the nutrition of alfalfa in Zamorano soils. Significant yield increases were obtained under limed and unlimed conditions, and ahigh and at low levels of P_2O_5 treatments. The largest yield changes occured on limed soils when K_2O was increased from 40 to 80 pounds per acre. The largest individual yield increase (37 percent) occured on the limed plots, which contained 80 pounds P_2O_5 per acre, when K_2O was increased from 40 to 80 pounds per acre.

The value of potassium fertilization is now known, but it remains to be determined at what levels diminishing returns to potassium commence. This is not not only the case with potassium the same information must be obtained for other essential plant nutrients. Now that is has been shown that alfalfa can be successfully grown under experimental conditions in Zamorano (figures 4 and 5), a study must be made as to the economic feasibility of growing alfalfa under actual field conditions given the diminishing returns data that will be forthcoming from future experiments with higher rates of phosphate and potash fertilization.

Figure 4: *Response of Check Plot*

Figure 5: *Response of Ca,* 0-40-80 *Plot*

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