ALFALFA IN THE YEGUARE RIVER VALLEY, IN HONDURAS

TERRANCE R. KVENVOLD

INTRODUCTION

On a trip to the Central American Republic of Honduras in 1964, the author was impressed with the fine work being done with alfalfa in the highlands of Central Mexico. Upon arrival at the Panamerican School of Agriculture, located in a sub-tropical highland valley in Central Honduras, the absence of alfalfa as a forage crop in a climate somewhat similar to that of Central Mexico, was inmediately apparent. The question of why such a fine source of high protein livestock feed was not being utilized required further investigation.

A preliminary investigation indicated that climate and soil types were not completely limiting factors in alfalfa propagation. In May 1965, this experiment reported herein was undertaken to determine if alfalfa could be grown in the area under a suitable plant nutrition schedule.

REVIEW OF LITERATURE

A large amount of research has been done in the U. S. concerning the effects of lime and fertilizer on various aspects of alfalfa production and quality. However, relatively little published data is available on similar research that has been carried out in the Central and South American republics. This is due primarily to the limited potentialities that exist for alfalfa propagation in these areas. Consequently, any review of literature in this area will be limited in length and contain primarily data published in Spanish.

Alfalfa is an economically important crop in the Southwetern United States and Mexico. Garza and Buller (8) obtained yields ranging from 1.75 — 4.00 tons per hectare per cutting (12 percent moisture material) under once a month cuttings. Heavy production in the first year under high fertilization was 26.46 tons per hectare of 12 percent moisture material. Ramírez and Laird (14) obtained air-dry yields of 29 tons per hectare annually with the application of 173 pounds per hectare of P_2O_5 and no K. According to extensive research, K has been found to be present in sufficient quantities for normal alfalfa production in Mexico. (6)

In New Mexico, Stroud, *et al.* (15) obtained yields as high as 8.5 tons dry matter per acre in 6 cuttings per year, and in California, Hinkle (9) obtained yields as high as 7.84 tons dry matter per acre annually.

The role of lime in alfalfa has been thoroughly tested in the United States, but little work with lime has been done in Latin America. Truog (16) states that the availability of all nutrient elements obtained by plants from the soil is influenced to some degree by the level of lime present. Nitrogen fixing bacteria need a pH of about 6.5 for satisfactory nitrogen fixation. Phosphorus is increasingly tied up by small declines in the soil pH at levels below 6.5 or increases above pH 7.5. Other nutrient elements are less affected by a pH drop, but optimum conditions depend upon a higher pH (6.5 -7.0)

Brown (4) states that lime and potassium have little effect on alfalfa seedling establishment, but are very effective in maintaining stands and yields. Brown (5) states that research in Maine on low pH soils has shown that levels of potassium can substitute for low levels of lime on soils derived from Calcarlous glacial till. Additional research has shown that liberal applications of potassium and lime have enabled researchers to obtain and maintain productive alfalfa on relatively poorly drained soils. Caravello and Alonso (7) report that the addition of 10 tons of lime per hectare increased alfalfa yields over 5 tons per hectare in 4 cuttings.

Potassium has not been found to be a seriously limiting factor in alfalfa production in the Southwest and Central America due to the fact that in the Southwest, soils are generally in a relatively unleached condition and therefore remain relatively high in potassium. In those Central American republics that have high rainfall, the soils are generally of volcanic origin and are naturally high in potassium. However, in those areas lacking naturally high levels of potassium, research indicates that potassium is a very critical element in alfalfa nutrition.

Tysdal (17) states that a ton of alfalfa removes approximately 35 pounds of potassium from the soil. Kresge *et al* Blaser, and Mitchell (11, 3, 12) state that the critical level of potassium in alfalfa plants for optimum growth is from 1.75 to 2.5 percent. Kresge, Bear, and Hopen *et al.* (11, 2, 10) indicate that if potassium is requiered, a split application is the most economical method of application.

Phosphorus is generally deficient in most alfalfa growing areas. Stroud (15) states that P fertilization, irrigation, and bacterial wilt are the three limiting factors of alfalfa production in California and much the same factors apply in Central America. Ramírez and Laird (14) found 210 kg P_{205}/ha to be the most effective rate of P fertilization in central Mexico while in Colombia, Baquen (1) found 200 kg P_{205}/ha to be the most effective rate. Hinkle (9) found that the addition of 135 pounds per acre of 44 percent superphosphate increased yields in New Mexico from 4.65 tons per acre to 7.84 tons per acre.

Whereas a split application of potassium has been reported to be most effective (10), such results from phosphorous fertilization are obtained when the total annual application is applied at the beginning of the growing season (9, 4, 13). Research done in Minnesota by MacGregor, Brownell, and Nelson indicates that annual fertilization of alfalfa is more desirable than fertilization every other year and that there is little difference in alfalfa yields between fertilization in the spring and in the fall. Mitchell and Blaser (12, 3) consider that plant phosphorus levels above 0.26 and 0.28 percent no longer constitute a limiting factor in alfalfa growth.

Many investigations have studied the best method of applying the required fertilizers. Brown (4) found that phosphorus banded in the row raised plant phosphorous levels, plant heights, and doubled dry matter yields over P broadcast and disked into the soil. However, several factors may restrict the use of this practice. Suitable banding equipment may not be available, time may be a critical factor — broadcasting and disking in requires less time.

Location, Methods, and Experimental Design

The experimental plots were located in a sub-tropical highland valley at an altitude of 2,500 feet on the lands of the Pan American School of Agriculture near Tegucigalpa, Honduras. Daily temperatures range from maximums of 83 — 87° F to a minimums of 60 — 62° F. Average annual rainfall is 44 inches, 90 percent of which falls during the period from May through November. Irrigation is essential from December through April.

Plot design is shown in figure 1. Average slope of the plot location is 3 percent, but because of surface irregularities, the plot site was land leveled twice prior to seeding. To eliminate fertilizer translocation effects due to surface runoff, drainage channels one foot wide and 6 inches deep were dug between individual plots. Individual plots were one rod square blocks. Four replicates of 14 different fertilization and liming treatments were laid out in a randomized block design. A three foot spacing was provided between replicates and a two foot spacing was provided between individual plots.

After corner stakes were set, individual blocks were laid out and the proper amounts of lime, superphosphate and potassium chloride were mixed in a five-gallon pail of surface soil from each block. This mixture was then spread on the surface of each block, (figure 2), as well as an insecticide, (heptoclor) at a rate of 4 pounds per acre. This was then incorporated into the surface three inches of soil in each block, using a tractor drawn disk harrow. Periphery stakes were used to re-establish block boundaries and a stake was placed at each corner of every block (figure 3).

Hairy Peruvian alfalfa was seeded at a depth of 1/4 to 1/2 inches with a Planter Jr. vegetable planter at exactly nine pounds per acre in 14 inch rows. This row spacing was selected to facilitate cultivation with a hand cultivator. For forage production, alfalfa is usually seeded in much narrower bands (6-7") or broadcast, but due to prior experience with weed control in this location, it was decided that some provision for cultivation must be retained.

Figure 1: *Experimental Design and Fertilizer Treatment**

Check	0-40-0	0-80-0	0-40-40	0-40-80	0-80-40	0-80-80
Lime	Lime 0-40-0	Lime 0-80-0	Lime 0-40-40	Lime 0-40-80	Lime 0-80-40	Lime 0-80-80
0-80-40	0-80-0	0-80-80	Lime 0-80-80	0-40-80	Check	Lime 0-80-0
Lime 0-80-40	Lime 0-40-0	0-40-0	Lime	Lime 0-40-40	0-40-40	Lime 0-40-80
0-80-0	Check	0-80-80	Lime 0-40-80	0-40-40	Lime 0-80-40	0-40-80
Lime 0-80-0	0-40-0	0-80-40	Lime	0-40-40	Lime 0-80-80	Lime 0-40-0
Lime	Lime 0-80-80	Lime 0-40-80	Lime 0-40-0	0-40-0	Check	Lime 0-80-0
0-40-40	0-80-0	0-80-0	Lime 0-40-40	0-40-80	Lime 0-80-40	0-80-40

* Pounds per acre of N. P_{205}, and K_2O, Lime Indicates pH adjusted to 6.4.

Figure 2: *Plot Preparation*

Figure 3: *General View of Experiment*

Directly after seeding, and in the absence of suitable mechanical packing equipment, the soil around the seed was firmed by a student walking on top of the rows. Germination was excellent and very rapid. Within five days, the individual rows of alfalfa could be seen from some distance.

Individual blocks were hand weeded at 2 week intervals because of a heavy infestation of weeds in the general experimental area. In addition, an unusual heavy infestation of army worms during the summer necessitated the use of an insecticide (Dipterex) on a weekly basis.

Physical and Chemical Properties of Zamorano Soil

The soils of the Zamorano region are as yet unclassified. Texturely, the soil in the experimental area is a loam formed from sediment which came from volcanic tuff in the slopes of the hills surrounding the valley. A dense clay subsoil presents a drainage problem in certain areas and makes land leveling almost mandatory.

A sample of the first 8 inches of the soil profile (composite of 5) showed the organic matter content of the test soil to be 2.6 percent, with a pH of 5.5 (H_20) or 4.6 (INKCL). Readily available P (NH F —HCL extraction) was 5 pounds per acre (low) while available Nitrate-N equals 20 pounds per acre. The test soil is relatively high in available K as indicated by a level of 480 pounds per acre.

One rate of lime was used. The amount of lime needed to raise the pH of the test soil to 6.5 was calculated and a total of 2.25 tons per acre of $CACO_3$ were applied. Three rates of P and of K were tested (0, 40, and 80 pounds per acre of $P_2\ 0_5$ or of K_20). Analysis of the superphosphate fertilizer used showed a P_20_5 content of 20.26 percent while the K_20 content of the potassium chloride used was 62.0 percent.

Harvesting and Plant Analysis

For harvesting, one yard square wooden frames 3 inches deep were constructed. These frames were then placed at randon within the given block and all plants within the frame were cut even with the top of the frame using a straight edge and a hand shears. Cuttings from each block were immediately weighed and a smaller sample taken to be used for dry matter and for protein content determination. Dry matter and protein content analysis were made by students working under the supervision of Dr. Abdul Bari Awan. * The first cutting was made 6 weeks after seeding and subsequent cuttings were at intervals of approximately one month.

Former EAP Professor of Soils.

The Effect of Lime Applications on Yield and Protein Content of Alfalfa

The importance of lime in alfalfa production has long been known and much published material is available on this subject. The effects of this in the Zamorano Valley were as expected, in that a statistical analysis of the data (tables 1 and 2) show a significant increase

Table 1 — Yield of alfalfa in response to fertilizers in El Zamorano

Treatment $N-P_2O_5-K_2O$ Pounds per Acre	Yield of Dry Matter Pounds per acre 1st Cutting	2nd Cutting	3rd Cutting	Total
Check	960 a	652 a	723 a	2335 a
0-40- 0	876 b	942 b	956 b	2774 b
0-80- 0	837 b	1023 b	1011 b	2871 b
0-40-40	875 b	942 b	1057 b	2874 b
0-40-80	1201 c	1115 c	1322 d	3638 d
0-80-40	1115 d	1044 b	1229 c	3388 c
0-80-80	1039 d	1204 c	1357 d	3600 d
Ca- 0- 0- 0	1186 d	1058 b	1197 c	3441 c
Ca- 0-40- 0	1203 c	1017 b	1247 c	3467 c
Ca- 0-80- 0	927 a	1220 c	1286 c	3433 c
Ca- 0-40-40	1107 d	1218 c	1324 d	3649 d
Ca- 0-40-80	1553 e	1294 d	1378 d	4225 e
Ca- 0-80-40	953 a	1257 d	1314 d	3524 c
Ca- 0-80-80	1624 e	1496 e	1705 e	4825 f

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

To obtain approximate green matter yields multiply by 5.

Table. 2. — Protein content of alfalfa in response to fertilizers in El Zamorano

Treatment $N-P_2O_5-K_2O$ Pounds per Acres	Total Yield Dry Matter Pounds per acre	Crude Protein * Percent	Crude Proteia Total Pounds per acre
Check	2335 a	18.16 a	424 a
0-40- 0	2774 b	19.92 a	553 b
0-80- 0	2871 b	19.11 a	549 b
0-40-40	2874 b	20.05 a	576 b
0-40-80	3638 d	20.59 a	749 c
0-80-40	3388 c	21.22 a	719 c
0-80-80	3600 d	21.39 a	770 c
Ca- 0- 0- 0	3441 c	23.66 b	814 c
Ca- 0-40- 0	3467 c	24.10 b	836 c
Ca- 0-80- 0	3433 c	24.65 b	846 c
Ca- 0-40-40	3649 d	24.43 b	891 d
Ca- 0-40-80	4225 e	25.18 b	1064 e
Ca- 0-80-40	3524 c	24.27 b	855 d
Ca- 0-80-80	4825 f	25.25 b	1218 f

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

* Average of three cuttings.

in alfalfa yields and protein content with the addition of lime. The addition of sufficient lime to raise soil pH to 6.4 (actual pH obtained) increased dry matter yields by 47 percent.* The check plots produced 2,335 pounds per acre dry matter, while those plots receiving only lime produced 3,441 pounds dry matter per acre in an average of the first three cuttings.

The effect of lime on alfalfa protein content was significant at the 5 percent level. Crude protein** content was increased 30.2 percent, from 18.2 percent to 23.7 percent, by the addition of lime (table 2). Similar increases in protein content were recorded by Baquen (1) in Colombia. The effect of liming on total crude protein production is a reflection of two factors: the effect of lime on protein content, and the effect on yields. Total crude protein was increased 91 percent, from 424 pounds per acre to 814 pounds per acre, by the addition of lime alone.

Data in table 1 show the lime increased yields as much as the 0-80-40 fertilizer treatment. The effect of lime on yields may or may not be the result of increased phosphate availability due to liming. Drake states that it would appear that the direct effect on phosphate availability produced by liming acid soils is probably less than the indirect effect produced by creating more effective conditions for increased production of plant residues and improved micro-organic activity.

*Average of three cuttings
** Whole plant.