

# High Phosphorus for Alfalfa

plant analysis used to evaluate phosphorus status of alfalfa fields as guide to fertilizing for better yields and returns

W. R. Sallee, Albert Ulrich, W. E. Martin, and B. A. Krantz

**Two field-scale tests** in Tulare County showed plant analysis to be a satisfactory means of measuring the phosphorus status of alfalfa.

High superphosphate rates paid off by bringing about maximum yields and profits.

Tissue analysis showed light superphosphate applications were insufficient to attain full yield potential. Such light treatments cost less—but were less profitable—than massive treatments which brought the alfalfa to completely safe phosphorus levels.

## Tests to Predict Needs

An intensive study was undertaken in 1955 to evaluate plant analysis as a means of predicting the necessity for and the effects of phosphorus fertilization on yield, quality, and composition of alfalfa.

These were replicated tests using plots of one complete irrigation check as unit of treatment. Harvest was made in the usual manner with the farmer's equipment but the hay from each treated plot was kept separate, so the bales could be weighed to provide yield measurements.

The tests showed that yields could be measured with precision—using field-scale techniques—provided treatments were properly replicated and bales from each plot were weighed separately.

At the time of each cutting, samples were taken to measure the phosphorus and protein status of the alfalfa.

A second field experiment was started in 1957 with an existing one-year-old stand of alfalfa on a Madera loam. Yield was only six tons per acre. Plant tissue analysis indicated phosphorus deficiency. Applications of superphosphate were made to provide a wide range of phosphorus rates from zero up to 320 pounds  $P_2O_5$ —available phosphoric acid—per acre. This experiment was designed to learn how much phosphorus could be used effectively on alfalfa, frequency of applications, and their effects on the crude protein and phosphorus content of the hay.

Applications of 320 pounds  $P_2O_5$  per acre gave increases of 4.5 to 5.2 tons per acre over a two-year period. There was no advantage in split applications. Yields were higher when all of the phosphate was applied the first year. Applications of 160 pounds and 80 pounds  $P_2O_5$  per acre over a two-year period produced significantly less alfalfa than did the 320-pounds per acre.

## Tests of 1957 Evaluated

Results of the 1957 test were evaluated using data from a Tulare County cost study. Alfalfa produced in the experimental field was valued at \$21 per ton. After deducting all costs of production, except interest, over a two-year period, there remained a gross profit of \$78.62 per acre for the control treatment, as compared to \$100 per acre with the light phosphate rate. With high phosphate fer-

tilization, the gross profit was \$126–\$129 per acre. The increase in profit due to fertilization over the two-year period amounted to about \$22 per acre for light fertilization, as compared with \$47–\$50 per acre where high phosphate fertilization was used.

After deducting annual interest charges of \$47.77 per acre on land and equipment, the unfertilized alfalfa in the experiment gave a total net loss of \$16.92 per acre in two years. In contrast, the heavily fertilized alfalfa returned a net profit of about \$30–\$33 per acre in two years, after deducting all operating and fertilizer costs plus interest on equipment and land valued at \$700 per acre.

## Composition

The average phosphorus content was increased from 0.15% in alfalfa from the control plot to 0.18% in the plots treated with the low rate of phosphorus application and to a high of 0.26% where 320 pounds  $P_2O_5$  per acre were applied over a two-year period. Only the 0.15% phosphorus value from the unfertilized alfalfa is in the class where the hay might not supply enough phosphorus for animal needs.

Calculations show that the 6.7 ton crop grown without fertilization removed approximately 46 pounds  $P_2O_5$  per acre each year. An adequately fertilized crop of nine tons of hay per acre removed approximately 100 pounds  $P_2O_5$  annually

Continued on next page

Effect of Phosphorus Fertilization on Yield and Profit in Alfalfa Production

Alfalfa Yields, Income, Costs, and Profit on Two-year Basis												
Fertilizer treatments		Alfalfa Yields			Gross income		less		Costs		Profit	
$P_2O_5$ /Ac.		Tons/Ac.			Value of alfalfa @ \$21/ton	Cost of fertilizer and application (1)	Baling costs (2) @ \$5/ton	Fixed cash and depreciation costs (3)	Gross profit /Ac.	Profit from fertilization \$/Ac.	Net profit /Ac. (4)	
1957	1958	1957	1958	Total								
check	check	6.29	7.05	13.34	\$280.14	\$ . . . .	\$66.70	\$134.82	\$78.62	\$ . . . .	\$16.92	
40	40	6.81	8.45	15.26	320.46	9.00	76.30	134.82	100.34	21.72	4.80	
80	80	7.40	9.29	16.69	350.49	17.00	83.45	134.82	115.22	36.60	19.68	
80 + 80*	80 + 80*	7.93	10.28	18.21	382.41	34.00	91.05	134.82	122.54	43.92	27.00	
160	160	7.79	10.07	17.86	375.06	33.50	89.30	134.82	117.44	38.82	21.90	
160 + 160*	. . .	8.03	10.54	18.57	389.97	33.50	92.85	134.82	128.80	50.18	33.26	
320	. . .	8.06	10.32	18.38	385.98	33.00	91.90	134.82	126.26	47.64	30.72	
* 2nd half about Aug. 1st.												
L.S.D. 5% level		.55	.57	1.03								

(1) Cost of superphosphate @ 10¢/lb.  $P_2O_5$ , plus application  $P_{40}$  and  $P_{80}$  @ 50¢/acre,  $P_{160}$  @ 75¢/acre, and  $P_{320}$  @ \$1/acre.

(2) Including \$5/ton for baling and roadsiding the hay for shipment.

(3) Including tractor expense for cutting, taxes, water and irrigation expense, plus depreciation @ \$67.41/Ac./yr.

(4) After deducting \$95.54 for interest at 6% on investment.

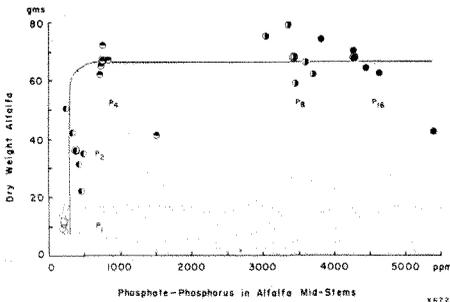
# ALFALFA

Continued from preceding page

from the soil. These calculations—when compared with the fertilizer applications made—indicate that 33%–43% of the added phosphate fertilizer had been removed in the crops harvested in the first two years of this study.

The average crude protein content of the alfalfa over a two-year period was increased from 15.4% to 17.4% by fertilization. At every cutting there were consistent increases. The total nitrogen removed in the crop of alfalfa without fertilization amounted to 325 pounds of

Relation of phosphate in midstems to yield of alfalfa in greenhouse solution culture experiment.



actual nitrogen per acre annually, or about 2,000 pounds of crude protein. Where fertilized adequately with phosphorus, about 500 pounds of nitrogen or 3,100 pounds of crude protein per acre were harvested annually.

## Critical Phosphorus Levels

Before plant analysis may be applied to alfalfa, it is necessary to know what parts of the plant should be analyzed, when the plants should be sampled, and the phosphorus composition associated with adequately supplied alfalfa, as well as with alfalfa known to be deficient in phosphorus. It was found in earlier greenhouse studies that the midstem of alfalfa was the plant part most sensitive to differences in phosphorus supply and that plants should be sampled at approximately one-tenth bloom to best reflect their nutrient status.

The relationship between phosphorus content and yield of alfalfa in a green-

house study is illustrated in the graph to the left. Yields were plotted to show how the phosphate content of the midstems changes as yields of alfalfa increase.

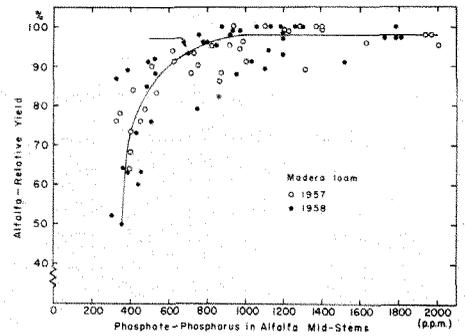
The vertical arm, or line, in the graph shows how yields increased rapidly with the first phosphorus application, while the phosphate content of the plant changed only slightly. This part of the curve is known as the deficiency zone. The horizontal arm of the curve shows

### Techniques of Field Sampling and Plant Analysis

A field of alfalfa should be divided into two or more segments of not over 20 acres each. Sampling should be done at one-tenth bloom or when one out of 10 plants has some open blossoms. Samples should be taken by walking across the center of the area collecting one complete stem of alfalfa at 35 different locations distributed at equal intervals. The mid-stem tissue is obtained by cutting out the middle third of the stem and stripping the leaves from it. Samples should be air dried or oven dried at 158°F and ground to pass a 40-mesh screen. Analysis for acid soluble phosphorus is made as described on page 49 of California Agricultural Experiment Station Bulletin 766. A free copy of Bulletin 766 may be obtained at the local Farm Advisor's Office or by a request sent to Agricultural Publications, 207 University Hall, University of California, Berkeley 4, California.

Madera loam give the same type of relationship of yield to composition. The curve plotted in the graph shown below is similar to the one from the greenhouse study. However, absolute yields were not used, because they vary from cutting to cutting throughout the season. Instead, yields were expressed on a relative basis, with the highest plot yield at each cutting taken as 100 and other yields calculated as percentages. The field curve has a broader transition zone, but the results for two successive years follow the pattern of the greenhouse study. The transition zone appears to extend from 400 ppm to approximately 900 ppm PO<sub>4</sub>-P with the critical-level indicated at approximately 700 ppm for field conditions in these tests.

Relation of phosphate in midstems to relative yield of alfalfa in a field test in Tulare County. The critical-level is indicated by the arrow at about 700 ppm of phosphate-phosphorus.



Plant analysis was helpful in interpretation of yield response to phosphorus application. Low rates of phosphorus application often gave excellent response in the first few cuttings in the spring but showed little response later in the summer. The phosphorus concentration in the midstem tissue dropped below the critical-level of 700 ppm in the later period, showing that the plants were not getting sufficient phosphorus during the summer months.

## Plant Analysis a Useful Tool

Plant nutrient surveys were made in fields throughout Tulare County to evaluate the phosphorus status of the alfalfa. Many fields were phosphorus deficient.

Concluded on page 13

Effect of Phosphorus Fertilization on Yield and Composition of Alfalfa

Fertilizer treatments		Av. annual yield of hay Tons./Ac.	Phosphorus or P <sub>2</sub> O <sub>5</sub> in hay				Crude protein or nitrogen in hay		
P <sub>2</sub> O <sub>5</sub> /Ac.			Av. % Total P	Annual P <sub>2</sub> O <sub>5</sub> removed in crop		Av. % recovery of P <sub>2</sub> O <sub>5</sub> applied	Av. % crude protein	Crude protein lbs./Ac.	Annual nitrogen removed in crop
1957	1958	Total		Due to treatment	Total				Due to treatment
check	check	6.67	.15	46.0			15.4	2050	328
40	40	7.63	.18	62.7	16.7	42	16.4	2506	401 73
80	80	8.35	.21	79.2	33.2	41	17.0	2831	453 125
80 + 80	80 + 80	9.11	.24	99.4	53.4	33	17.2	3131	501 173
160	160	8.92	.25	102.5	56.5	35	17.4	3113	498 170
160 + 160	...	9.29	.26	108.9	62.9	39	17.4	3225	516 188
320	...	9.19	.26	110.9	64.9	41	17.4	3188	510 182

tions occurred in all treatments including the check but the differences between the treatments did not appear significant.

The heads of Double Dwarf 38 are characteristically tight and compact. In the test field many heads were covered by the dense foliage, which made it almost impossible to apply liquid insecticides thoroughly to the heads. Furthermore, most of the larvae in the field were mature or nearly mature at the time of treating. Many of the larvae were leaving the plants to pupate. This factor alone undoubtedly accounted for much of the difference in numbers of larvae between the pre- and post-treatment counts of the check. The age of the larvae undoubtedly influenced the degree of control, because mature larvae are more tolerant of certain insecticides than are the younger larvae.

Excellent control of the corn earworm was obtained in the RS610 variety with

DDT spray and dust—each 98.8%—followed closely by Phosdrin—97.1%—and Thiodan—95%. Guthion with 84.9% and Dylox with 89.1% gave the poorest control. The RS610 variety produces heads on stalks high above the foliage. The heads are loose and not as compact as those of Double Dwarf 38. While a much heavier infestation was in the RS610 field the larvae were mostly immature—first to third instars—at the time of treatment.

From these experiments it appears that DDT is highly effective in reducing numbers of corn earworm larvae in grain sorghum heads. However, spray applications of DDT result in significant residues on the grain at harvest. Although residues on threshed grain were extremely small in the dusted plots, Federal regulation prohibits any residue.

The results of these tests indicate that Phosdrin, Thiodan, and perhaps Dylox

are materials that could be substituted for DDT. Dust formulations of these materials were not tested, but it is possible that dusts may prove to be superior to airplane spray applications in penetrating the grain sorghum heads.

To achieve maximum control, fields should be treated while the larvae are small and before extensive feeding damage has occurred in the heads. The presence of small larvae can be detected readily without removing the heads from the plant by jarring the heads over a pan.

*Oscar G. Bacon is Associate Professor of Entomology, University of California, Davis.*

*Raymond Miskus is Laboratory Technician in Entomology, University of California, Berkeley.*

*Morton D. Morse is Farm Advisor, Butte County, University of California.*

*Robert L. Sailsbery is Farm Advisor, Glenn County, University of California.*

*W. D. Riley, Principal Laboratory Technician in Entomology, University of California, Davis, cooperated in the studies reported here.*

## LIME

Continued from page 9

should be more friable and easy to cultivate. Power requirements for tillage should be reduced and seedbed preparation less difficult. No plant differences could be attributed to the changes in physical condition but greenhouse methods minimize the effect of physical condition on yield.

Samples of the same three soils—Colusa silty clay, Yolo silty clay loam, and Capay clay—were tested for hydraulic conductivity by the laboratory method of determining the flow of water through a column of soil to gain information on the permeability of soils. As was the case with modulus of rupture, some soils are affected more favorably than others by the addition of lime. The permeability of a soil is increased by the addition of lime, the first increment of 10 tons per acre being practically as effective as larger amounts. Hydraulic conductivity and modulus of rupture data indicate an improvement in the physical conditions of some soils.

Because the tomato plants showed an increase in growth, which could be attributed to the phosphate, the phosphorus content of 23 samples of sugar beet by-product lime—representing old and new production—was determined chemically.

Sugar beet lime may contain from 0.06% to 0.64% phosphorus or an average of 0.38% phosphorus. An application of 10 tons per acre of sugar beet lime may add to the soil some 12 to 128 pounds of phosphorus per acre or, expressed as phosphorus pentoxide, from 27.5 to 313 pounds per acre. Laboratory and greenhouse studies indicate that this phosphate is readily available.

It is evident that modulus of rupture and permeability of some soils can be improved by lime applications and other soils may be improved only slightly or show no change. At present, there is no test or measurement that can be readily utilized to determine which soils might be changed favorably by lime applications. While increased yields may not result from this improvement, cultivation and seedbed preparations may be somewhat easier. No adverse nutritional effects could be demonstrated.

Sugar beet by-product lime can not be considered a fertilizer and the response obtained in these studies might be nutritional rather than a result of physical improvement of the soil. The percentage of phosphate in sugar beet by-product lime varies—even from the same refinery—and there is no assurance that the lime will always contain a uniform concentration of phosphorus.

*A. L. Brown is Specialist in Soils and Plant Nutrition, University of California, Davis.*

*T. R. Nielsen was Assistant Professor of Soils, University of California, Davis, when these studies were conducted.*

*E. Halevy was Senior Laboratory Technician in Soils, University of California, Davis, at the time of these studies.*

## DISTRICTS

Continued from page 11

ness of district agricultural production to one or more of the external economic conditions.

*Michael F. Brewer is Assistant Professor in Agricultural Economics, University of California, Berkeley.*

*The foregoing is based on a research project financed in part by the Water Resources Center of the University of California.*

## ALFALFA

Continued from page 8

At such locations growers applied phosphate fertilizers, and yield responses were observed. The survey indicated also alfalfa fields where phosphorus application was not needed. Strip tests with superphosphate were tried in many such fields and—in no case—was a response to fertilization obtained.

Plant analysis shows real promise as a means of evaluating the phosphorus status of alfalfa fields and as a guide for the development of improved fertilization practices.

Samples of alfalfa plants for tissue analysis must be collected at the one-tenth bloom stage—the ideal time for hay harvest—or when one out of 10 plants is in bloom. In spring or fall the plants are in a growth stage comparable to the one-tenth bloom period when the small regrowth shoots, growing up from the plant crown, are  $\frac{1}{4}$ "– $\frac{1}{2}$ " in length. The soluble phosphate concentration in the midstem tissue will be too high in alfalfa plants sampled before the one-tenth bloom stage and, at more mature stages of growth, the phosphorus readings will be too low. The critical values reported in this article apply only to alfalfa plants in the one-tenth bloom stage of growth.

*W. R. Sallee is Farm Advisor, Tulare County, University of California.*

*Albert Ulrich is Plant Physiologist in Soils and Plant Nutrition, University of California, Berkeley.*

*W. E. Martin is Extension Soils Specialist, University of California, Davis.*

*B. A. Krantz is Extension Soils Specialist, University of California, Davis.*