SAMPLING SOIL BY DEPTH FOR ALFALFA: ITS POTENTIAL

Hugh W. Hough, Associate Professor, Soils
University of Wyoming

ABSTRACT

Bayard fine sandy loam, Greyback gravelly loam, and Lost Wells sandy clay loam which receive pH 8.0 irrigation waters were sampled at 30 cm intervals to 90, 120 or 180 cm, respectively one to three years after treatment. Sewage sludge, steer manure, cheese plant effluent, and 0-45-0 were used to supply phosphorus up to 300 kg/ha. Recommended, 2x recommended, 3x recommended, and 4x recommended amounts of irrigation water with an SAR less than 2 were applied. Sodium bicarbonate extractable phosphorus was measured on all soil samples.

The sodium bicarbonate P values decreased as depth increased on all treatments on all soils. Relative available phosphorus contents at specific soil depths were very similar for all soils. The relative P values were regressed on the respective soil depths and the r^2 values reported. A graph was constructed with one line for each of four sampling depths showing the percent that their relative phosphorus amount was of the cumulative phosphorus amounts for each succeeding depth in the profile. Using the soil depth, the sample depth, the soil P test value, and information from this graph, it is possible to obtain a good estimate of the amount of available phosphorus in the profile for alfalfa.

INTRODUCTION

A soil testing system for phosphorus should measure the appropriate soil phosphorus concentrations and enough other soil characteristics so that a valid phosphorus fertilizer recommendation can be made for a specific alfalfa crop management system. Most fertility specialists would have similar interpretations for the various subsidiary conditions, but nearly all are tied to the phosphorus measurement of the upper six inches of soil. However, alfalfa is one of the deeper rooted crops with a high phosphorus requirement. The other crops in the irrigated rotation tend to do their phosphorus feeding at more shallow depths which makes the surface soil phosphorus test more reliable for them. A suitable phosphorus testing system for alfalfa should verify those soil horizons where test values correlate well with any graded series of treatments that change phosphorus levels of the soil.

EXPERIMENTAL CONDITIONS

The soils being considered in this study were sampled to 90 cm at Torrington, 120 cm at Thayne, and 180 cm at Riverton. The minimum pH in any horizon was 7.5, while the pH of the irrigation waters was 8.0. The drainage condition ranged from moderate to well with intermittently perched water tables attainable in some irrigation seasons at one site. All sites have been used for irrigated alfalfa production, but not all were supporting alfalfa during the phosphorus sampling period. The mean annual air temperatures in degrees Celsius were 3.7 at Thayne, 5.6 at Riverton, and 8.9 at Torrington.

The irrigation waters were readily available when needed at all lcoations. The sodium adsorption ratio (SAR) values were 2 or less at all sites. The irrigation season specific conductance extremes over all sites were from 15 to 75 mS with no greater spread than 50 mS for any site (USGS, 1974). Surface irrigation techniques were used at Riverton and Torrington while sprinklers were used for weekly effluent applications at Thayne. The irrigations at Torrington were initiated when 50% of the available moisture remained in the surface horizon and continued until field capacity was reached. At Riverton, 10% and 50% of available moisture remaining were used for initiating irrigation -- with three of the 50% initiation plots receiving the following amounts of water -- replacement only, two times replacement, or four times replacement (Delaney, et al., 1978). The weekly effluent sprinkler applications at Thayne were 3 to 4 times the replacement water requirements depending on season (Borrelli, et al., 1978).

The combination of alkaline soils and alkaline waters containing 75 to 200 mg HCO_3L^{-1} applied at 45 to 60 cm per irrigation season was able to move phosphorus deeper in the profile (Delaney, et al., 1978). This feature was accentuated in all the trials by large applications of phosphorus containing materials (sewage effluent, sewage sludge, steer manure, 0-45-0) or by applying water in amounts on some treatments that exceeded the evapotranspiration and leaching requirements (Borrelli, et al., 1978) (Delaney, et al., 1978).

RESULTS

Sodium bicarbonate extractable phosphorus (Olsen and Sommers, 1982) was evaluated at the end of the growing season at Torrington, before spring growth and after the last forage harvest at Thayne for two years, and at the end of the third alfalfa growing season at Riverton. Mean values for three replications at Torrington and four replications at Thayne and Riverton were recorded in Table 1.

Table 1: Sodium bicarbonate extractable P (mg kg^{-1}) for locations, soil depths and treatments shown.

Location[1]	Soil depth cm.	KgP/ha from sewage sludge 0	106	212	318	KgP/ha from steer manure 0	95	190	285
Torrington	0-30	6.8	23.2	58.2	41.8	7.1	15.7	39.3	43.6
(Bayard fine	30-60	3.6	12.9	32.5	44.3	4.3	11.7	24.3	21.1
sandy loam)	60-90	5.0	3.9	10.7	7.5	3.6	7.5	7.5	8.9

		Sequential Kg effluent P added by sprinkler/ha: 0 Spring 1976	+34 Fall 1976	+89 Spring 1977	+31 Fall 1977
Thayne	0- 30	16	34	65	89
(Greyback	30- 60	9	16	17	32
gravelly	60- 90	4	7	13	21
loam)	90-120	5	4	13	5

		112 Kg P/ha as 0-45-0 applied 3 years before these final samples: Limited H_2O	Recommended H_2O	2 X Rec. H_2O	4 X Rec. H_2O
Riverton	0- 30	18.0	14.1	9.4	12.8
(Lost Wells	30- 60	3.6	5.9	6.5	4.0
sandy clay	60- 90	2.4	3.9	3.4	3.4
loam)	90-120	2.0	6.2	5.9	5.3
	120-150	3.6	2.8	5.6	7.2
	150-180	2.4	4.4	2.5	4.0

[1] Replications: Torrington 3, Thayne and Riverton 4.

In order to make the desired comparisons, the following conversion were performed on the P concentration data for each soil treatment:

Depth, cm.	Line 1.	Depth, cm.	Line 2.
30	$(P_{0-30} \div P_{0-30})100=$		
60	$(P_{0-30} \div P_{0-60})100=$	60	$(P_{0-60} \div P_{0-60})100=$
90	$(P_{0-30} \div P_{0-90})100=$	90	$(P_{0-60} \div P_{0-90})100=$
120	$(P_{0-30} \div P_{0-120})100=$	120	$(P_{0-60} \div P_{0-120})100=$
150	$(P_{0-30} \div P_{0-150})100=$	150	$(P_{0-60} \div P_{0-150})100=$
180	$(P_{0-30} \div P_{0-180})100=$	180	$(P_{0-60} \div P_{0-180})100=$

Depth, cm.	Line 3.	Depth, cm.	Line 4.
90	$(P_{0-90} \div P_{0-90})100=$		
120	$(P_{0-90} \div P_{0-120})100=$	120	$(P_{0-120} \div P_{0-120})100=$
150	$(P_{0-90} \div P_{0-150})100=$	150	$(P_{0-120} \div P_{0-150})100=$
180	$(P_{0-90} \div P_{0-180})100=$	180	$(P_{0-120} \div P_{0-180})100=$

Then the resulting data for the respective lines was used to calculate semilogarithmic regression lines using the centimeters depth as the linear component and the calculated percentages in the logarithmic component. More than one location was involved in each line shown in Figure 1. The equations obtained for each line follow:

Line 1. $y = 107.96 \times 10^{-0.00281x}$, $r^2 = 0.72$

Line 2. $y = 138.34 \times 10^{-0.00236x}$, $r^2 = 0.84$

Line 3. $y = 166.97 \times 10^{-0.00247x}$, $r^2 = 0.86$

Line 4. $y = 168.28 \times 10^{-0.00192x}$, $r^2 = 0.80$

Table 2: Extreme r^2 values for the effect of sampling depth on the proportions of profile $NaHCO_3$ P determinations.

Depth, cm.	Thayne			Torrington			Riverton		
	Best	Worst	Combined	Best	Worst	Combined	Best	Worst	Combined
0-30	0.98	0.87	0.84	0.99	0.83	0.85	0.99	0.94	0.73
0-60	0.99	0.94	0.91			0.61	0.99	0.97	0.82
0-90			0.67				0.99	0.95	0.78
0-120							0.99	0.94	0.81
0-150									0.91

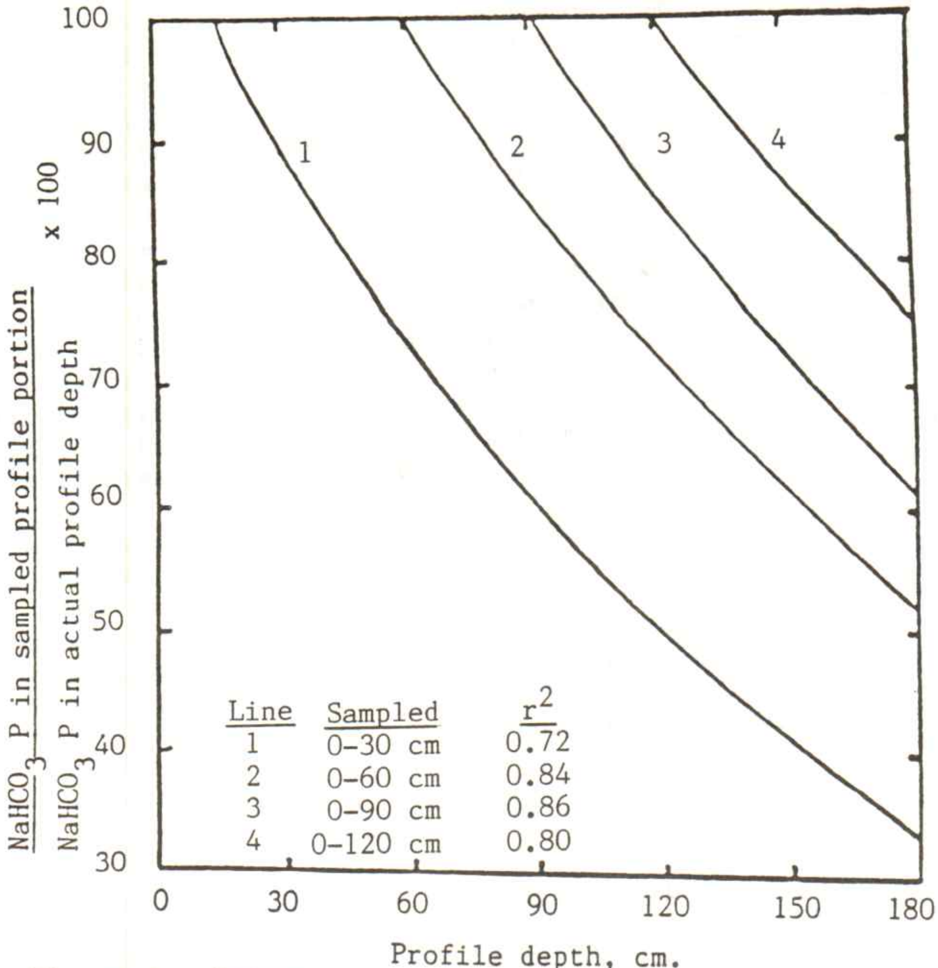

Figure 1: Effect of sampling depth on proportion and reliability of profile $NaHCO_3$ P determinations.

DISCUSSION

The test results shown in Table 1 demonstrate a decrease in phosphorus concentration as profile depth increases fo all treatments at all locations. An evaluation of the consistency of this decrease was desired. It was believed that the variety of phosphorus materials and rates applied with the range of water rates and climatic conditions present would cover any possible conditions found in production fields from which growers would be sending samples to the soil testing laboratory. If this decrease in phosphorus concentration with depth was definable in a generalized way, then how could the relationship with sampling depth be used in evaluating the available phosphorus content of the soil for agronomic management for alfalfa?

Regressions of the transformed P analysis data on soil depth for individual treatments within soils as shown in Table 2 can have relatively high r^2 values with some spread as treatments differ. Combining all treatments data by sites or for all sites had similar effects on the resultant r^2 values (Table 2) (Figure 1). The all--sites combination possesses higher r^2 values for the 0-60 cm or the 0-90 cm sampled profile portion than for the 0-30 cm or the 0-120 cm sampled layers (Figure 1).

The relationships between the phosphorus content of sampled soil portions and the distribution of available phosphorus throughout the profile as shown in Figure 1 seem to be quite stable for the sites studied. To use this information in a soil testing and phosphorus fertilizer recommendation program for alfalfa, it will be necessary to have a reasonable estimate of the effective rooting depth for the site. Soil survey information and experience with the area can be helpful, but irrigation induced perched water table behavior can complicate the situation. Spot check probing may be required to find the effective rooting depth for certain production fields. With reasonable rooting depth information in hand, the user can choose a soil sampling program.

For example: The distribution of available phosphorus in the 120 cm profile is 50% in the 0-30 cm layer, 20% in the 30-60 cm layer, 15% in the 60-90 cm layer and 15% in the 90-120 cm layer. Pulling samples by horizon or interval to the full 120 cm depth would allow the analyst to provide a complete list of the chemically available phosphorus for the profile. Time, expense, and surficial soil variability tend to discourage this approach. However, laboratory analyses for phosphorus from shallower samples could be converted to profile estimates by use of multiplying factors--i.e. 2 for 0-30 cm sample or 1.43 for 0-60 cm sample or 1.1 for 0-90 cm sample. The r^2 values for the 30, 60, and 90 cm samples were 0.72, 0.84, and 0.86, respectively (Figure 1).

The soil testing laboratory supervisor can really have the analyses performed and operate the recommendation system in a timely fashion if the soil history questionnaire or information sheet is complete. Sampling and rooting depths could be missing. Pursuit of this missing information can be time consuming or fruitless so use of default options with attendant footnotes might become standard alternate practices. System design by the specialist will be critical for the fact of the profile phosphorus distribution to be beneficial to the grower.

REFERENCES CITED

1. Borrelli, John, Robert D. Burman, Ronald H. Delaney, Joseph L. Moyer, Hugh W. Hough and Barron L. Weand. 1978. Land application of wastewater under high altitude conditions. United States Environmental Protection Agency, Robert S. Kerr Environmental Research Laboratory, Ada, Ok. EPA-600/2-78-139.

2. Delaney, Ronald H., James J. Jacobs, John Borrelli, Richard T. Clark and Warren E. Hedstrom. 1978. Economic and agronomic effects of high irrigation levels on alfalfa and barley. University of Wyoming Agricultural Experiment Station Research Journal 121.

3. Olsen, S.R. and L.E. Sommers. 1982. Phosphorus, chapter 24, Agronomy Monograph #9, Methods of Analysis, Part 2 - Chemical and microbiological properties, Second edition. American Society of Agronomy, Madison, WI.

4. United States Department of Interior Geological Survey. 1978. Water resources data for Wyoming Part 2. Water quality records. U.S. Geological Survey, 4015 Warren Avenue, Cheyenne, WY.