DEVELOPING SPATIAL AND TEMPORAL SOIL AND PLANT SAMPLING STRATEGIES FOR YOUR FARM

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ABSTRACT

Soil and plant sampling has traditionally been carried out at the field scale level which attempts to get an average characterization of a field regardless of size. Recent Global Positioning System (GPS) technology provides for returning to a specific location in a field within 1-2 yards or meters. Yield measurements of several crops are being recorded for areas 5-20 square yards or meters in size or less. Grid sampling of soil at one point for every 2-5 acres is widely practiced in some parts of the United States. The experimental use of some of these techniques will be presented and developing strategies for use on any given farm will be discussed.

Key Words: alfalfa, soil fertility-plant nutrition, fertility management, soil sampling, plant sampling

INTRODUCTION

Much concern and effort has been devoted to 'getting a representative soil or plant sample' from a field. In the main, the objective was to obtain an 'average' value of the soil pH, available phosphorus, potassium, or some other characteristic for the field in question or perhaps the nutrient concentrations of plants growing in a field. It was suggested that extremely different areas in the field be avoided and sampled separately for if the field was being farmed as a unit, it should be sampled as a unit. Many had observed that two to four-fold or more differences in crop yield existed in each field being managed as a unit. Managing as one unit meant that the whole field was fertilized the same, irrigated the same, planted the same and the same rates of pesticide were applied. Site specific management is the phrase often used to characterize managing a field by addressing the differences between its subunits. These subunits are usually several acres (2-5) in size, sampled at a single point in the middle on a rectangular grid basis with dimensions of 300 to 600 feet. Because of the larger number of soil or plant samples generated by this procedure along with the cost of analyses, the economic benefits have been questioned. Growers and researchers are currently evaluating sampling strategies to determine the cost-benefit ratios given different variations and heterogeneity within fields. The objective of this presentation is to share the results of some research that can be utilized in the development of sampling strategies for individual fields or farms.

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RESULTS AND DISCUSSION

The most typical approach being used in site specific management is to begin by taking soil samples on a rectangular grid. An example of the spatial variation in a field is illustrated by the results of grid sampling for available soil phosphorus in Figure 1. A 25 acre alfalfa field had previously been planted to three replications of five varieties in a randomized block design with the strips sixty feet wide and 1200 feet long. Along the center of each strip soil samples were taken in early March 1997 every 60 feet for a total of 20 samples. The 300 samples (15 strips X 20 samples/strip) were analyzed for available phosphorus and a statistical program used to draw the contour lines at 5 ppm intervals shown in Figure 1. Only 10 out of the 300 samples had phosphorus test levels of 10 or below. Twenty of the 300 locations having a range of 6 to 38 ppm bicarbonate-P were selected where small paired plots of no phosphorus and 300 lbs P_2O_5/A was applied on March 30, 1997. Figure 2 illustrates the results of the midstem PO_4-P concentrations and alfalfa yields 64 days after phosphorus was applied to the twenty locations plotted against the initial soil test levels. Note that there was nearly a 1000 ppm increase in the PO_4-P concentration on the sites where the soil test level was less than 20 ppm. Note also that yields were no different between the areas receiving no phosphorus and the 300 lbs P_2O_5/A rate even when the soil test was less than 10 ppm.

Figure 1. Soil bicarbonate-P concentrations given in 5 ppm contours based on 300 samples (60' x 60' grid) taken between February 28 and March 12, 1997. Dots indicate the 20 test locations.

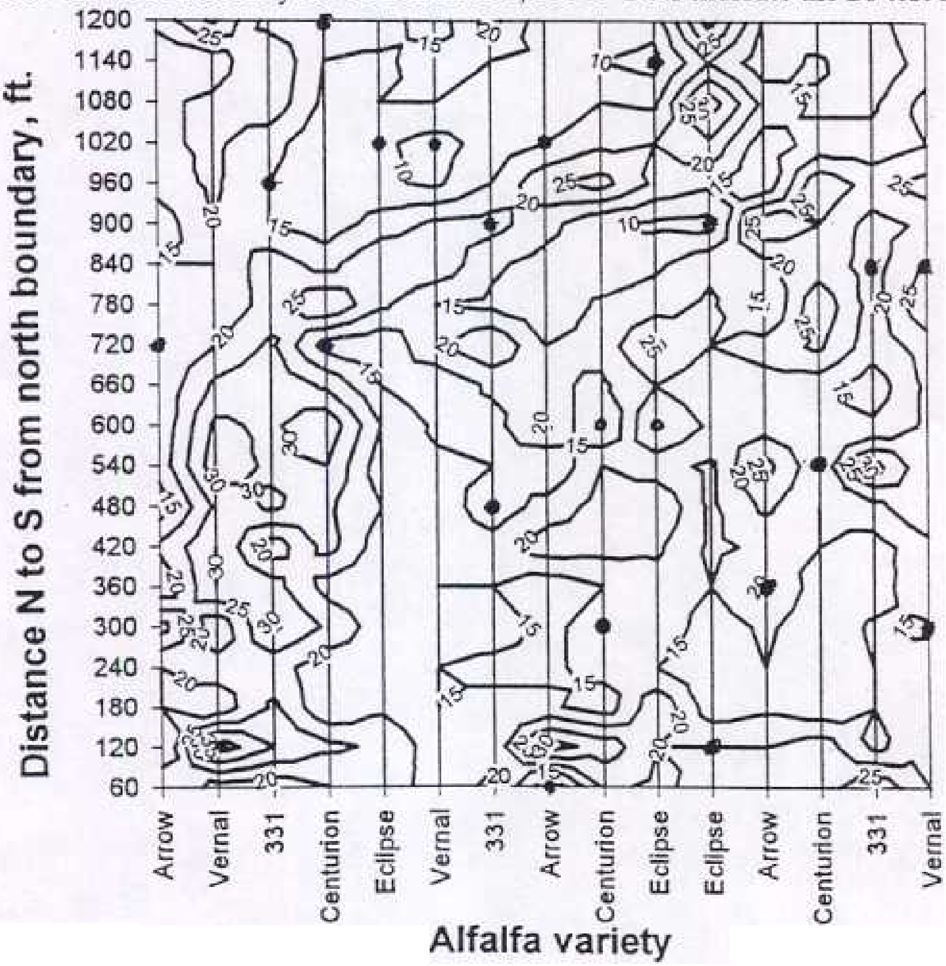
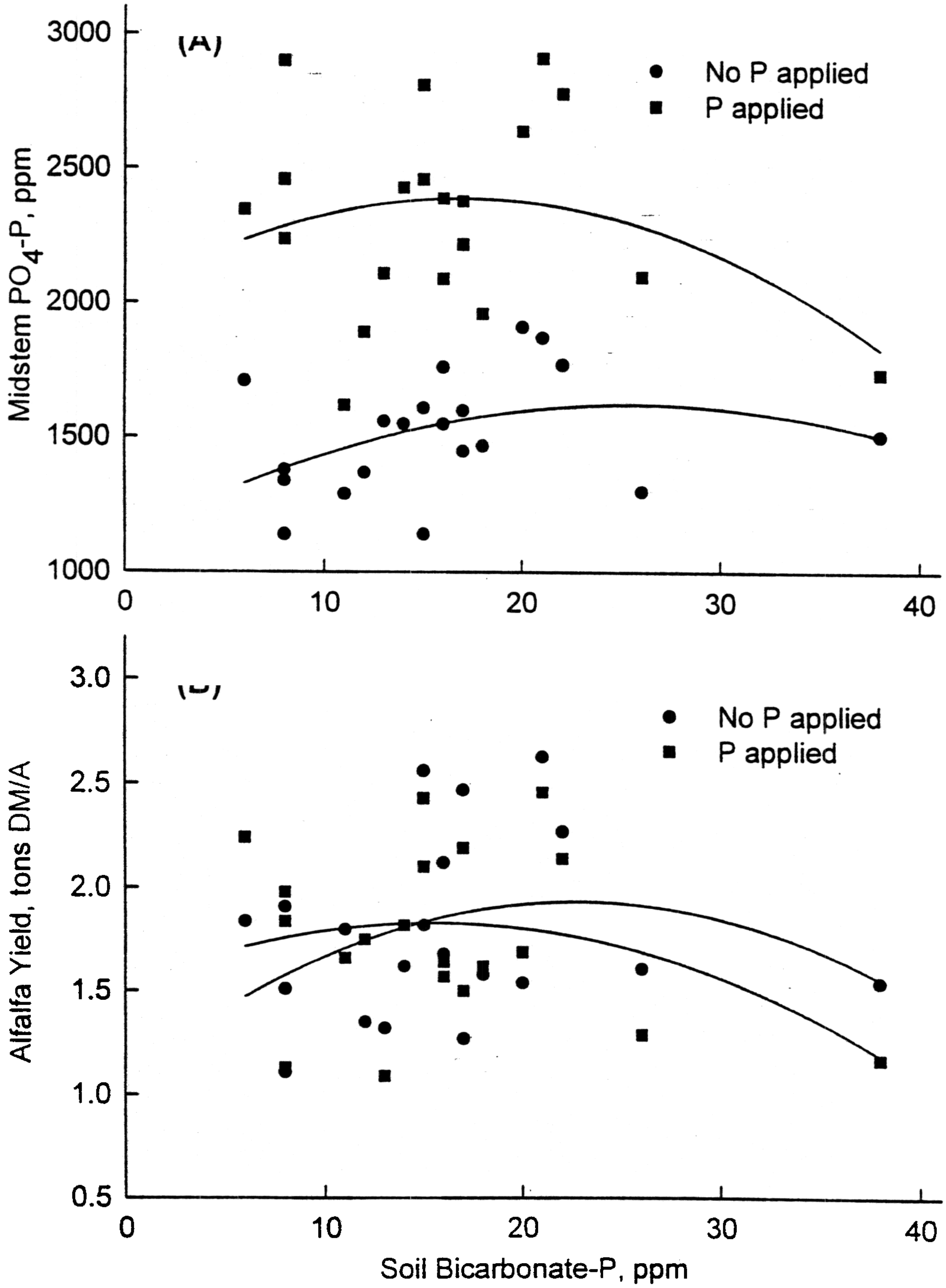


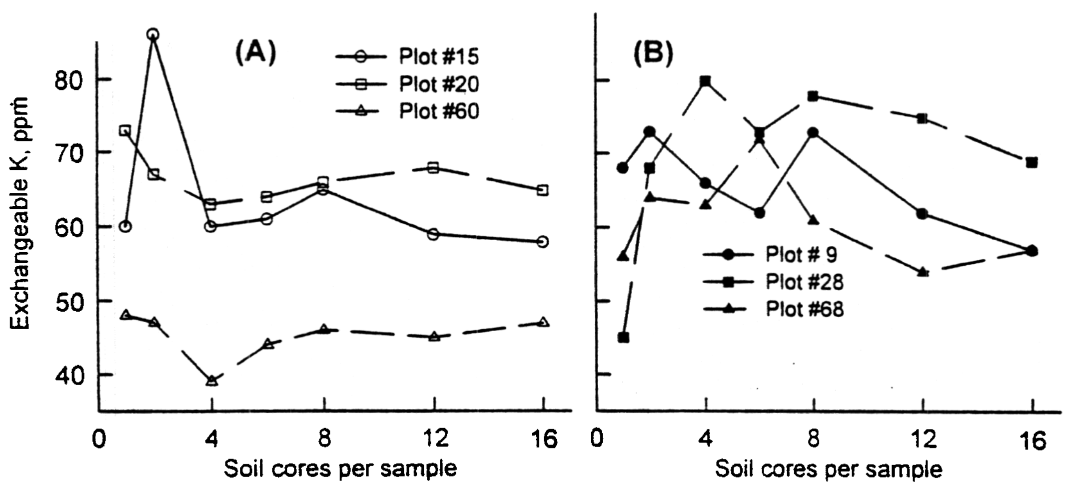
Figure 2. Alfalfa midstem PO_4-P concentration (A) and yield (B) on May 30, 1997 as influenced by the bicarbonate-P soil test level at the twenty locations where no phosphorus and 300 lbs P_2O_5/A were applied on March 27, 1997.



Another approach being used in site specific management is to measure the yield of the crop throughout the field. Corn, wheat, potato, and tomato are several of the most frequently measured crops where yields are monitored and field maps are prepared. The biggest advantage with yield monitoring is that the crop is used to identify growth problems. Although soil fertility levels may be responsible for some yield reductions, inadequate or excessive soil moisture, weeds, diseases or insects may contribute to changes in crop yield. Yield monitoring is being used to more successfully address the reasons for lower crop yields and direct management intensity for better economic returns.

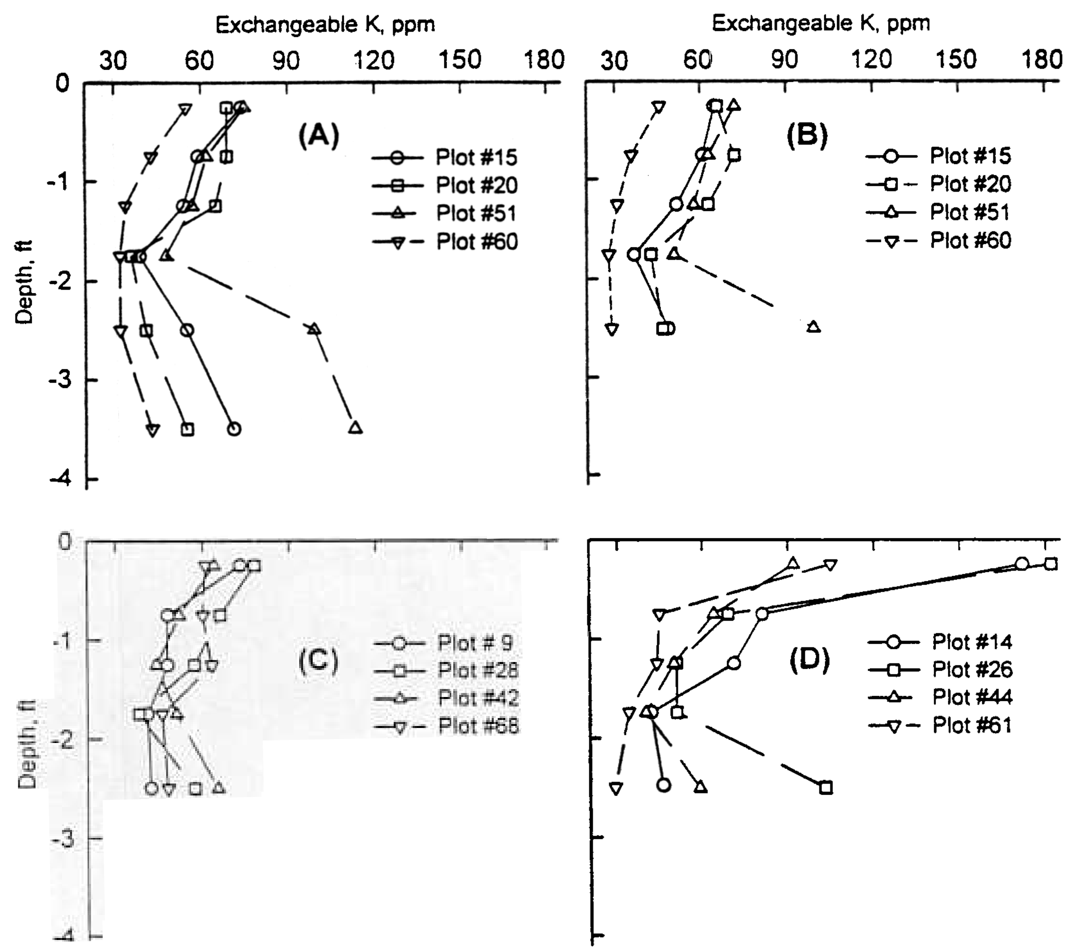
One of the more frequently asked questions when considering site specific management is how many soil cores should be taken for each sample, is one, two, five, ten or more required? Figure 3 gives the results of a series of soil samples taken from six field plots each measuring 15' by 20' in size following two treatments. Three randomly located plots received no potassium and three others received applications of 200 lbs K_2O/A on February 22, 1995 and February 15, 1996. Samples were composed of either 1, 2, 4, 6, 8, 12 or 16 cores from each of the six plots. It can be noted that in general, the fewer the number of cores the greater the potential variation in soil test level for exchangeable potassium.

Figure 3. Exchangeable potassium concentration of soil samples from (A) control plots and (B) plots receiving 200 lbs K_2O/A on February 22, 1995 and February 15, 1996 as influenced by number of 3/4" cores per sample on April 1-2, 1997 (0-6" depth).



Another source of spatial variation is the one of soil depth. Although plants derive a major portion of their nutrients from the surface foot of soil and soil samples are taken from this depth, deeper rooted crops such as alfalfa may obtain considerable quantities from deeper depths. Figure 4 illustrates the results of soil samples taken on June 7, 1995 and April 1-2, 1997 from the plots which received no potassium and analyzed for exchangeable potassium

Figure 4. Exchangeable potassium concentration in soil samples from different depths in plots receiving no potassium taken on (A) June 7, 1995 and (B) April 1-2, 1997; and plots receiving (C) 200 and (D) 800 lbs K_2O/A/yr for 2 years taken on April 1-2, 1997.



Note the spatial differences in exchangeable potassium on two sample dates where no potassium was applied (Figure 4A and 4B). Plot #51 recorded a much higher alfalfa yield during the 2 years of the study than the other plots receiving no potassium and it is undoubtedly because of the higher potassium levels in the third and fourth foot of soil. Figure 4C and 4D indicate that 200 lbs K_2O/A/yr of applied potassium did not increase soil test levels but that applications of 800 lbs K_2O/A/yr did result in increases of exchangeable potassium but only in the surface six inch layer.

In addition to the spatial variations of field sampling, temporal variations must also be considered. Fields seldom yield the same any two years in a row, seasons are different each year. Table 1 illustrates the exchangeable potassium concentrations in soil samples (0-6" depth) over time for four replications of 3 potassium treatments: the control where no potassium was applied, the 200 and 800 lbs K_2O/A. Note the change in soil test levels in the control plots (#15, 20, 51, and 60) where no potassium was applied on the three sample dates. Note also the lack of change for the plots receiving 200 lbs K_2O/A as well as the increase in the plots receiving 800 lbs K_2O/A. Alfalfa removal of potassium was approximately 100 to 120 lbs K_2O/A/yr from the control plots, about 250-280 lbs K_2O/A/yr from the plots receiving 200 lbs K_2O/A/yr and 350-380 lbs K_2O/A/yr from the plots receiving 800 lbs K_2O/A/yr.

Table 1. Exchangeable potassium concentration in soils sampled on 2/15/96, 6/7/96 and 4/12/97 following fertilizer applications on 2/22/95 and 2/15/96 (0-6" depth, 10 cores/sample).

Field Plot #	Fertilizer Treatment (lbs K_2O/A)	Exchangeable K, ppm		
		2/15/96	6/7/96	4/1-2/97
15	0			65
20	0			66
51	0			72
60	0			46
9	200			73**
28	200			78**
42	200			64**
68	200			61††
14	800			172**
26	800			182**
44	800			92**
61	800			105††

* Fertilizer applied on 2/22/95
† No fertilizer applied
** Fertilizer applied on 2/22/95 and 2/15/96
†† Fertilizer applied on 2/15/96

Yet another source of variation that is of primary concern to soil and plant tissue testing laboratories is producing consistent results over time. Table 2 gives the results of exchangeable potassium from the same soil subsampled and placed within large sets of samples at periodic intervals and submitted to the laboratory for analysis. Note that for the most part the concentrations were in the range of 54 to 63 ppm but one was 73 ppm, somewhat out of the range.

Table 2. Exchangeable potassium concentration in the same bulk soil which was subsampled and submitted on various dates to the laboratory at the indicated frequency.

Sample set number	Sample number in set	Date sample set was taken	Date sample set was submitted	Date results reported	Exchangeable K concentration (ppm)
1	17	2/15/96	6/3/97	7/8/97	59
1	36	“	“	“	73
1	59	“	“	“	54
2	7	6/7/96	6/3/97	7/14/97	59
2	21	“	“	“	58
		4/1-2/97	5/28/97	7/7/97	
		“	“	“	
		“			
		“			
		4/1-2/97	5/28/97	7/7/97	
		“	“	“	
		“			
		“	“		
		4/1-2/97	5/28/97	7/7/97	
		“	“	“	

SUMMARY

Perhaps after a discussion of several of the spatial and temporal sources of variation one would become frustrated and decide to make no change in what has been done in the past. More thought to the question will probably prevail and some changes might be considered. Perhaps the first question to address is ‘how much variation is in each field and what is the impact on crop yield and therefore profit?’ In alfalfa, the answer may be arrived at in several different ways. How much distance is there between bales coming out of the baler? assuming that the same cutting width is going into each windrow. Of course, the bale weights will vary but this may start the thinking process. It will give some indications however as to what areas of the field(s) are giving higher yields and which areas have lower yields. The next step may be to mark these higher and lower yielding areas on a map of the field, take some soil and plant tissue samples from an identified benchmark area perhaps 100’ X 100’ in size in the two production areas. It may be beneficial if soil samples are taken at several different depths like 0-6”, 6-12”, 12-24” and 24-36”. Observe other factors that may be affecting alfalfa growth like the presence of disease, insects, etc. These introductory steps may lead to a more comprehensive investigation but keep the cost-benefit ratio in mind as you make more advanced moves.

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