INFLUENCE OF PHOSPHORUS SOIL TEST LEVEL ON THE PROBABILITY OF CORN YIELD RESPONSE

Ron Gelderman
Manager, SDSU Soil Testing Program

Jim Gerwing
Extension Agronomist/Soils

ABSTRACT

Data from a long term residual phosphorus study was analyzed to determine the probability of a corn yield response at low, medium, high and very high soil test levels. Analysis of 55 rate-site years showed a corn yield increase 59, 22, 43 and 17% of the time respectively for low, medium, high and very high soil test categories. The very high soil test category is defined as a Bray P soil test of greater than 20 ppm. The results suggest that the current South Dakota State University recommendation of no phosphorus fertilizer above a 20 ppm soil test level for corn is appropriate.

INTRODUCTION AND OBJECTIVE

Soil test levels are often reported on a relative scale of low, medium, high or very high. Usually there is a number associated with these categories such as a low phosphorus test may be 0-10 ppm P, medium 11-15 ppm P etc. Frequently, however, it is not clear what the probability of a yield response to a given nutrient will be in any given soil test category.

Recently the states of North Dakota, South Dakota and western portions of Minnesota published a joint fertilizer recommendation system. Included in that recommendation system was the expected probability of response in the defined soil test categories from very low to very high (Table 1). The probability of a response is defined as greater than 80% when soil test levels are very low and declines to less than 20% when soil test levels are very high. Phosphorus soil test levels of less than 6 ppm are considered very low while tests greater than 20 ppm are in the very high category.

The objective of this paper is to analyze the corn yield response data from a long term phosphorus rate study on corn in South Dakota to determine the probability of a yield response to low, medium, high and very high soil test levels.

Table 1. Soil Test Interpretation for Phosphorus SD, ND, Western MN

Soil Test Level[1] ppm	Category	Probability of Response %
0-5	Very Low	>80
6-10	Low	60-80
11-15	Medium	40-60
16-20	High	20-40
21 +	Very High	< 20

[1] Bray 1

METHODS

A phosphorus rate study was established on the southeast South Dakota Experiment farm near Beresford in 1964. Phosphorus fertilizer rates of 0,23,46,92, and 183 pounds P_2O_5 per acre per year were applied each year from 1964 to 1967. Total phosphorus applied per treatment was 0, 92, 183, 366 and 732 pounds P_2O_5 per acre. No phosphorus was applied after 1967. Phosphorus was broadcast and incorporated by moldboard plowing. Tillage over the 28 years ranged from moldboard plowing and chiseling earlier in the experiment to ridge till more recently.

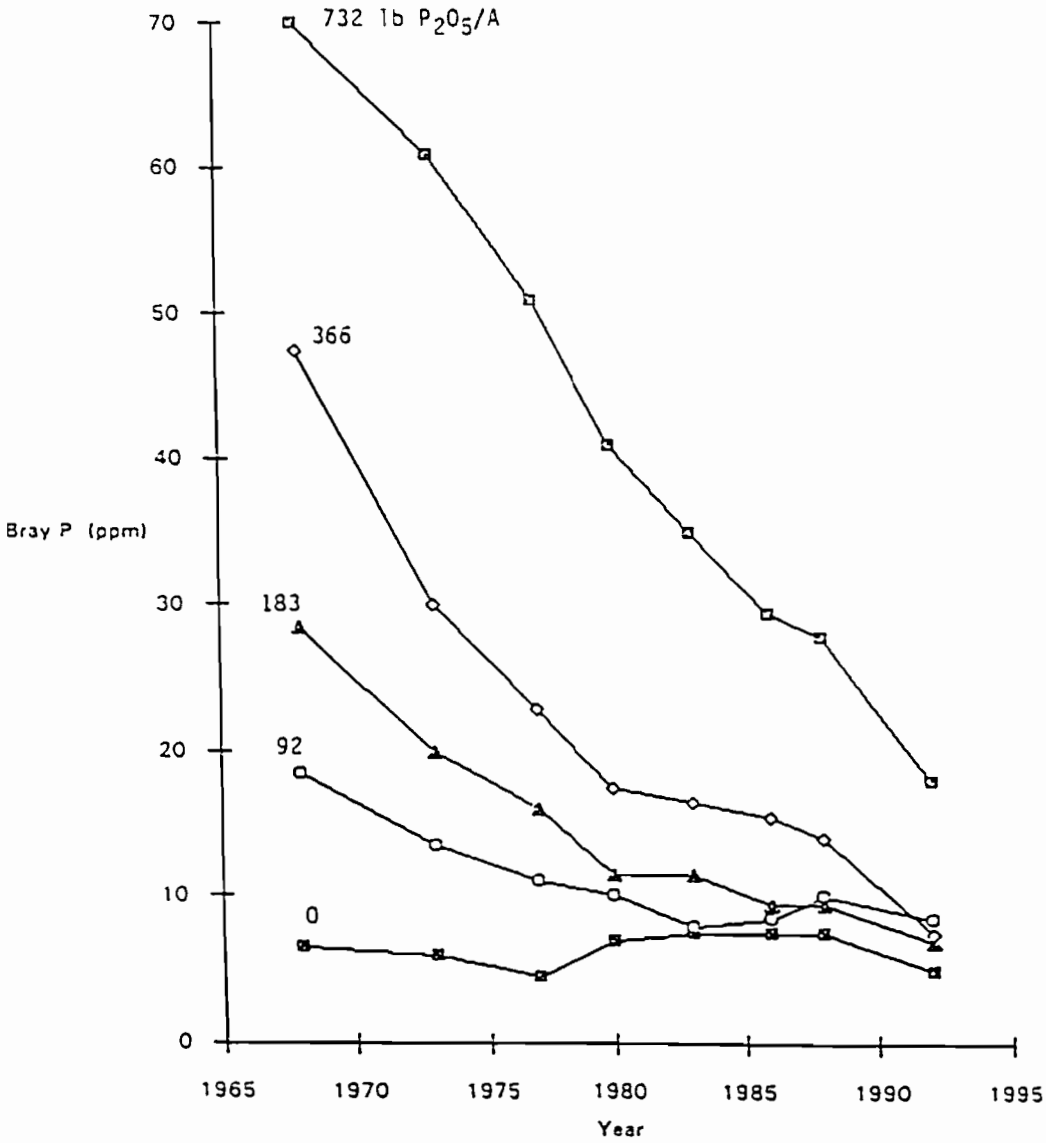
Experimental design is a randomized complete block with four replications. Plot size is 60 feet by 80 feet. Soil type at the site is an Egan silty clay loam. Crops grown over the last 28 years included 11 years of corn rotated occasionally with alfalfa, soybeans and sorghum. The response data evaluated in this paper is from the 11 corn years. Soil phosphorus test levels were monitored approximately every four years during the study. Soil samples were usually taken in the fall to a depth of four inches and the Bray 1-P soil test procedure was used for analysis.

RESULTS AND DISCUSSION

The initial phosphorus soil test level was 6.5 ppm in 1968. The added fertilizer phosphorus over the 4 year period increased soil test levels as expected (Fig. 1). The highest rate of P_2O_5, 732 pounds, increased the soil test level to 70 ppm.

Soil test levels have continued to decrease over time for the 183, 366 and 732 lb treatments. The 92 lb phosphorus treatment soil test declined until 1983. Since that time it has remained constant at about 9 ppm. The higher the initial soil test level (1968), the more rapid was the decline. The 0 phosphorus treatment soil test level has remained relatively constant between 6 and 8 ppm over the 28 year period.

Fig. 1. Soil test P as influenced by the initial P applications and time.



Corn yields for the 11 years it was produced on the site are listed in Table 2. Yields averaged approximately 100 bu/a. Corn yields were not significantly ($P < 0.05$) influenced due to phosphorus addition in any individual year except in 1982 in which yields were extremely variable due to weed competition. Mean corn yield over all years, however, was significantly influenced by the initial phosphorus rates (Table 2). The observation that treatment was significant on the overall analysis of variance but not for individual years may be explained by the trend of increasing yield due to treatment for many years. The 160 pound phosphorus rate increased corn yield an average of four bushels per acre over the 11 years.

Table 2. Yield of corn as affected by initial application of P fertilizer, long term P study, Beresford, SD

P_2O5[1] Rate	Year 1969	1979	1982	1983	1984	1985	1986	1987	1988	1989	1991	Mean
lb/a	Corn Yield, bu/a											
0	76	130	96	102	103	119	113	108	26	84	80	94
92	84	120	102	97	101	117	113	112	27	87	87	95
183	83	126	93	103	102	126	111	107	23	88	82	95
366	83	128	93	106	109	131	113	113	28	89	90	98
732	87	130	84	107	117	129	114	115	23	91	92	99
Stat Sign [2]	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	*[3]

1) Initial treatments consisted of 0, 23, 46, 92 and 183 lb/a P_2O_5 applied in each of the years 1964 - 1967.
2) * = Significant at $P < 0.05$, NS = Non Significant
3) The analysis of variance was done for mean yields by using individual years as replicates.

For the purpose of correlating yields over years to soil test categories, grain yields in bushels per acre were converted to percent of maximum yield (Table 3). A yield response was then considered as any treatment yield less than 95% of maximum yield within a crop year.

Table 3. Corn Yield expressed as a percent of Maximum yield within a site year, long term P study, Beresford, SD

P_2O_5 Rate	Year 1969	1979	1982	1983	1984	1985	1986	1987	1988	1989	1991	Mean [2]
lb/a	%											
0	87	100	94	95	88	91	99	94	93	92	87	95
92	77	92	100	91	86	89	99	97	96	96	95	96
183	95	97	91	96	87	96	97	93	82	97	89	96
366	95	98	91	99	93	100	99	98	100	98	98	99
732	100	100	82	100	100	98	100	100	82	100	100	100

[1] Initial treatment consisted of 0, 23, 46, 92 and 183 lb/A P_2O_5 applied in each of the years 1964-1967
[2] The mean values were calculated from mean yields of table 2.

The probability of a yield response for a soil test category is shown in Table 4. Best fit regression curves for the soil tests in Figure 1 were used to interpolate soil tests for each year. Frequency of yield response was then determined within a soil test category. Frequency of yield response is related to soil test levels. The low soil test produced a response 59% of the time while those in the very high category only produced a response 17% of the time. Of the two responses on very high testing soils, (Table 3) one occurred in the drought year of 1988 and the other in 1982 when weed infestations produced high experimental error. Excluding the results from these two years, the probability of response in the very high soil test category becomes 0%.

Table 4. Summary of 11 years of corn data with each treatment in each year as a data point,long term P study, Beresford,S.D.

Soil Test Category	Soil test range	No. of treatment years	Avg. P soil test	No. of responding treatments*	Response Frequency
	ppm		lb/a		%
low	5.1 - 10	27	7.6	16	59
Medium	10.1 - 15	9	12.4	2	22
High	15.1 - 20	7	17.7	3	43
V. High	> 20.0	12	37.0	2	17

* Responding treatments are considered those treatments that produced less than 95% of maximum yield within a crop year.

SUMMARY

Results of this long term residual phosphorus study show that frequency of corn yield response is related to soil phosphorus tests. The results also suggest that the current Bray P-1 soil test is correctly calibrated and the tri-state (South Dakota, North Dakota, western Minnesota) phosphorus fertilizer recommendations in which no P is recommended above a 20 ppm soil test are appropriate.

PROCEEDINGS OF THE TWENTY-SECOND NORTH CENTRAL EXTENSION - INDUSTRY SOIL FERTILITY CONFERENCE

November 18-19, 1992, Holiday Inn St. Louis Airport

Bridgeton, Missouri

Volume 8

Program Chairman and Editor:

Ray Lamond
Department of Agronomy
Throckmorton Hall
Kansas State University
Manhattan, KS 66506