YIELD OF IRRIGATED CORN DOUBLE CROPPED WITH SOYBEANS IN RELATION TO PHOSPHORUS FERTILIZATION

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Prior research on soil test interpretation has involved unirrigated crops, in most cases (2). Thus, more information is needed to determine the maximum level of phosphorus (PI required for high yields of corn under irrigation. When maximum P requirements are established, response models can be used to estimate the maximum economic levels of P fertilization for a given selling price of corn and cost of fertilizer P. Simplification of yield response models of corn to P can be accomplished by combining soil test P with fertilizer P added and defining the value as "P fertilization level".

There are three concepts of soil testing: a) cation saturation ratio, b) nutrient maintenance and c) nutrient sufficiency level (4). The nutrient sufficiency concept holds the greatest promise for providing maximum economic yields. Regular surveillance is required to keep the soil above the sufficiency level.

The nutrient sufficiency level varies with soil group, crop species, and perhaps even varieties of the same species. A fertility index is used by Alabama researchers to rate the nutrient level of each group of soils for each crop (2). The fertility index is defined as the per cent of sufficiency and is based on the relative yield of the crop. Thomas and Peaslee (5) present a generalized rating for soil test P with the double acid extractant in ppm-P: low 0-16, medium 17-37, and high >38 (ppm x 2.24 = kg/ha). These ratings correspond to fertility index ranges of 60-70, 80-100, and 110-200, respectively, from Cope and Rouse (2).

Ellington (3) summarized research data on crop response to P. A soil in Virginia, testing in the medium range of extractable P, produced 117 bu of corn/A (7338 kg/ha) with no fertilizer P and 142 bu/A (8906 kg/ha) with 120 1b-P_2O_5 /A (60 kg-P/ha). Another soil, testing 11 lb-P/A (12 kg-P/ha), produced 73 bu of corn/A (4579 kg/ha) with no fertilizer P and 149 bu/A (9345 kg/ha) with 82 lb-P/A (92 kg/ha) added as fertilizer. Irrigation was not mentioned in his report.

A statistical procedure is described by Cate and Nelson (1) for dividing soil test correlation data into two groups. One group has a high probability of response to the nutrient in question and the other a low probability of response. The dividing line between the two groups is referred to as the critical level of the nutrient being tested. A simple iterative process is used to obtain a series of R^2 values for divisions made at various 1 vels of soil test P. The critical level of soil test P is that where R^2 is maximum and this should be close to the 100% sufficiency level.

The objectives of this research were: a) to observe the relationship between grain yield of irrigated corn, double cropped with soybeans, and soil test P plus fertilizer P (P fertilization level), b) determine critical P fertilization levels (PFL) of two hybrids of irrigated corn in different years and c) calculate maximum economic PFL for irrigated corn.

METHODS

Four phosphorus (P) fertilization treatments were applied to irrigated corn during 1980-1983. Soybeans were planted in July following corn harvest each year, except 1983. Treatments were located on the same plots each year. Annual P application rates were 0, 30, 60 and 120 kg/ha. Potassium (K) was applied to all plots at the rate of 420 kg-K/ha each year. Method of application for P and K was broadcast and incorporated before planting. Magnesium sulfate was applied to supply 67-kg-Mg/ha and 90 kg-S/ha each year. Zinc sulfate supplied 9 kg-Zn/ha annually. Calcitic limestone was applied when needed to maintain soil pH above 6.0. All fertilizer was applied to the corn, whereas soybeans were produced with the residual.

Pioneer brand '3369A' was planted 17 March 1980 and 10 March 1981. Ring Around brand 'RA1604' was planted 17 February 1982 and 5 April 1983. Plant population was 86,450 plants/ha with row widths of 20 cm and 71 cm in an alternating pattern.

Total annual application of N was 336 kg/ha applied as follows: 84 kg-N/ha, per application, at emergence, 4, 6 and 8 weeks after emergence. Boron was applied at the rate of 2.25 kg-B/ha.

Soil type was Ruston loamy fine sand, thick surface, (fine loamy siliceous, thermic, Typic Paleudult). Conventional tillage methods were used for corn production in order to incorporate the broadcast P and K, while soybeans were grown with minimum tillage procedures. Soil samples were taken each February and analyzed for pH and double acid extractable P. Sprinkler irrigation was applied to recharge the plow layer when soil water suction reached 20 cb as measured at the 15 cm depth with tensiometers.

The experimental design was a randomized block with four replications. Regression analyses of yield versus PFL were run for individual years using the response model Y = A + B log PFL, where Y = yield in kg/ha. Values for PFL were divided into two groups according to relative yield to give one group with a low probability of response to additional fertilizer P and one with a high probability of response. The Cate-Nelson procedure was used to determine the group boundary which is referred to as the critical PFL (1).

Maximum economic PFL's were calculatd from individual years for corn prices of $2.00 and $3.00 per bushel (approx. $0.08 and $0.12 per kg) and a price of $0.57/lb of P ($1.25/kg). When the product of the first derivative of the regression equation referred to above and the ratio of corn price to P cost equals one, maximum economic PFL occurs. If the value is above one, maximum economic PFL has not been reached, if below one, it has been exceeded.

RESULTS AND DISCUSSION

Yield, expressed in terms of treatment means, had the largest difference between highest and lowest in 1982 (Table 1). The range was 8,028 kg/ha (130 bu/A) to 13,861 kg/ha (221 bu/A), these were also the highest and lowest yields for the duration of the experiment. Overall average yields were higher in 1982-83 than in 1980-81. The correlation between yield and PFL was significant in 1980 (P = 0.05), 1981 (P = 0.01) and 1983 (P = 0.01) but it was not significant (P = 0.05) in 1982.

Table-1. Yield of irrigated corn with four levels of applied P for two hybrids during 1980-83.

Applied P	Hybrid: Pioneer 3369A 1980	Pioneer 3369A 1981	RA 1604 1982	RA 1604 1983
	kg/ha[1/]			
0	9,722	8,530	8,028	9,345
30	10,913	10,600	12,293	9,220
60	10,851	11,039	13,861	12,293
120	11,478	11,666	13,736	12,858

1/Average of four replications.

The critical PFL's as determined by the Cate-Nelson (1) procedure were 21 kg-P/ha in 1980, 36 in 1981, 119 in 1982 and 85 in 1983. Since both hybrids were not grown the same year, I am not sure that the large differences between years were due to hybrids.

Maximum economic PFL's for the price of corn at $0.08/kg ($2.00/bu) were 50 kg-P/ha in 1980, 125 in 1981, 150 in 1982, and 100 in 1983. With the price of corn at $0.12/kg ($3.00/bu), maximum economic PFL's were 100 kg-P/ha in 1980, 200 in 1981, 225 in 1982 and 175 in 1983.

The range in critical PFL was much greater than the range in maximum economic PFL on a relative basis. There was almost a fivefold increase from lowest to highest critical PFL, while the maximum economic PFL increased twofold at $0.08/kg for corn and 1.25-fold at $0.12/kg.

Critical PFL's for 1980-81 were in the low range of the generalized rating system of Thomas and Peaslee (5). However, critical PFL's in 1982 and 1983 were in the high and medium ranges, respectively.

Soil test levels of P for the treatment that received the annual application of 120 kg-P/ha increased substantially after the first application and slight increases were observed each year thereafter (Table 2). Phosphorus soil test levels for the other three treatments showed increases in 1981 and 1982 with substantial decreases occurring in 1983. The 30 and 60 kg-P/ha application rates had about the same level of soil test P in

1983 as in 1981. Plots that received no P fertilizer had mean soil test levels that were identical in 1980 and 1983.

Table-2. Soil test levels of P sampled in February of each year before fertilizer was applied to irrigated corn.

Applied P	Year 1980	1981	1982	1983
	kg/ha[a]			
0	23	40	62	23
30	27	44	73	41
60	33	54	97	53
120	18	98	107	112

[a] Average of four replications.

Hydrogen ions in the double acid extractant greatly increase the solubility of all calcium phosphates and the sulfate ions seem to prevent readsorption of phosphate removed by other ions (5). Soil pH at sampling was between 5.0 and 5.5 in 1980 and 1983, while in 1981 and 1982 it was between 6.0 and 6.3 Soil P shifts from Ca-P to Al-P and Fe-P, which are less soluble than Ca-P, as pH decreases. This is a possible explanation for the higher soil test P levels in 1981 and 1982.

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Literature Cited

1 - Cate, R. B., Jr. and L. A. Nelson. 1971. A simple statistical procedure for partitioning soil test correlation data into two classes. Soil Sci. Soc. Amer. Proc. 35:658-660.

2 - Cope, J. T., Jr. and R. D. Rouse. 1973. Interpretation of soil test results. In: L. M. Walsh and J. D. Beaton (eds.) Soil testing and plant analysis. Soil Sci. Soc. Amer. Inc. Madison, WI. pp. 35-54.

3 - Ellington, C. P. 1978. Crop yield response to phosphorus. In: Phosphorus for agriculture a situation analysis. Potash and Phosphate Institute, Atlanta, GA. pp. 25-41.

4 - Olson, R. A., K. D. Frank, P. H. Grabouski and G. W. Rehm. 1982. Soil testing philosophies: consequences of varying recommendations. Crops and Soils. October. pp. 15-18.

5 - Thomas, G. W., and D. E. Peaslee. 1973. Testing soils for phosphorus. In: L. M. Walsh and J. D. Beaton (eds). Soil testing and plant analysis. Soil Sci. Soc. Amer. Inc. Madison, WI. pp. 115-132.