Fertilizer Experiments with Corn on Several Soils in Indiana, 1963-1965[1]

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The primary purpose of this research was to study the response of continuous corn (*Zea mays* L.) to phosphorus and potassium fertilization on several different soils in Indiana. Barber and Humbert (1), after reviewing advances in the knowledge of potassium fertilization from 1951 to 1961, concluded that more data are needed on the relationship between crop response to added potassium and the level of available potassium in the soil. On a Runnymede loan testing medium in potassium, Stivers and Griffith (7) found that it took four years of cropping with continuous high yielding corn before a significant yield increase with potassium fertilizer was obtained. It was thought that ths soil might have fixed potassium since the increase in available soil potassium, after four years of applying 100 pounds per acre of potassium annually, was small. Barber and Humbert (1) state that soil type may have to be considered more in the future because of the relationship between soil type and potassium fixation and potassium release.

Barber and Stivers (2) have reported that broadcast and plow under phosphorus fertilizer is more important than row phosphorus fertilizer for corn when more than 17 pounds per acre of phosphorus is applied. At low soil test levels, corn yields were increased by row applications of phosphorus, but not a medium and high levels.

Methods and Procedures

Different rates and placements of commercial fertilizers were applied to soils on field plots on which corn was grown. Height, yield of grain and chemical composition of the ear leaf were determined.

These experiments were conducted on three different farms, all of which were in Tippecanoe County (Table 1). The phosphorus fertility and the potassium fertility experiments on the Gwin Farm were adjacent to each other at the same location. The Byers and Brown farms experiments were initiated in 1963; the two experiments on the Gwin Farm were initiated in 1964.

One of the three replications on the Byers Farm was on Fincastle soil, and two replications were on Russell soil (Table 1). On the Gwin Farm, no clear demarcation between Martinsville and Russell soils was made. The two soils are very similar except that Martinsville has coarser parent material in the D horizon and is slightly more droughty than Russell.

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TABLE 1.
Description of Soils.

Experiment	Year initiated	Farm and address	Previous crop	Soils	Purdue Soil Test Values: Soil pH	P Lbs. per A.	K Lbs. per A.
P and K fertility	1963	H. Byers Lafayette, Ind.	Wheat and red clover	Fincastle and Russell	Av. = 5.6 Range = 5.0–6.7	17 (Very low) 8–39	106 (Low) 65–183
P fertility	1964	C. Gwin Lafayette, Ind.	Alfalfa and orchardgrass	Martinsville and Russell	Av. = 6.6 Range = 6.1–6.9	38 (Low) 15–350	155 (Medium) 104–253
K fertility	1964	C. Gwin Lafayette, Ind.	Alfalfa and orchardgrass	Martinsville and Russell	Av. = 6.6 Range = 6.0–7.1	27 (Low) 17–56	116 (Low) 84–227
P and K fertility	1963	E. R. Brown Lafayette, Ind.	Corn	Crosby	Av. = 5.7 Range = 5.1–6.4	12 (Very low) 4–55	85 (Low) 48–116

On the Crosby soil location and on the Fincastle and Russell soils location, three replications were used. Experimental design was an unbalanced incomplete block design with 28 treatments. A randomized complete block design with four replications was used for the Martinsville and Russell soils experiments. All plots were 65 feet long and four 42-inch corn rows wide. The center two rows minus five feet for border on each end were harvested.

Soil samples were taken prior to the start of each experiment from every plot. Fifteen or more cores were taken seven inches deep in each plot and composited for one sample. They were then air dried, screened and mixed, and subsamples were tested by the Purdue Soil Testing Laboratory using methods of Spain and White (5, 6).

On the Fincastle and Russell soils having a pH of 5.6, two and one-half tons of agricultural limestone were applied before plowing, and one and one-half tons of limestone were applied after plowing in 1963. On Crosby soil agricultural limestone was applied at the rates of one and one-half tons per acre before plowing and three-fourths ton per acre after plowing in 1963. In 1964, three and three-quarters tons per acre of agricultural limestone were applied to the same soil and plowed under for the phosphorus and potassium experiments.

Fertilizer materials used were 33.5 percent nitrogen from ammonium nitrate, 24 percent phosphorus from superphosphate in 1963 and 1965 and 9 percent phosphorus from superphosphate in 1964, and 50 percent potassium from muriate of potash.

Two hundred pounds per acre of nitrogen was applied on all experiments each year prior to plowing. An additional ten pounds per acre of nitrogen was applied beside two of the four corn rows of all treatments in each plot in 1963 on both the Crosby soil location and on the Fincastle and Russell soils location. Rates of broadcast phosphorus and potassium fertilizer were applied in only one year, 1963, on the Crosby soil location. All broadcast phosphorus and potassium fertilizers were applied in the spring, half before plowing and half after. On the Martinsville and Russell phosphorus fertility experiment, 598 pounds per acre of potassium was broadcast. On the potassium fertility experiment on the same location, 120 pounds per acre of phosphorus was broadcast and 40 pounds per acre of P was used in the row. In all experiments where row fertilizer was used, it was applied approximately two inches horizontally away from the seed at planting.

Aldrin granules for controlling soil insects were broadcast on plowed ground and disked in immediately prior to planting on all experiments conducted in 1964. Broadcast atrazine spray after planting to control weeds was applied to both Martinsville and Russell soils experiments in 1964 and to the Crosby experiment in 1965. Conventional cultivation and hand hoeing were used on all experiments as needed to control weeds.

Funks G-96 and Indiana 678 corn hybrids were used for seed on all experiments in 1963 and in 1964 respectively. Pfisters Associated Growers Sx29 was used on the Crosby location in 1965.

Stands per acre counted at harvest were approximately 16,200 on the Crosby location in 1963, 19,800 in 1964, and 16,300 in 1965. Final stands on the Martinsville and Russell experiments in 1964 were approximately 16,000 plants per acre. On the Fincastle and Russell location final stands were approximately 16,500 plants per acre.

Dates of planting on the Crosby location were June 4 in 1963, May 22 in 1964, and May 13 in 1965. The Martinsville and Russell soils location was planted May 29, 1964. The Fincastle and Russell soils location was planted May 24, 1963.

Height measurements were made on the tallest extension of leaves of each of 10 or more plants within the harvest area of each plot of all replications.

Composite corn ear leaf samples of 15 or more leaves per treatment taken at the green silk stage, were ground and then sent to the Department of Agronomy, Ohio Agricultural Research and Development Center, Wooster, Ohio, for analyses.

For yield determination, ear corn was hand harvested. Weights and moisture percentages in the grain were determined, and yields were calculated using Remmenga's tables (3).

Results and Discussion

These experimental sites were selected because they had low or very low soil test values for the fertilizer nutrient being studied, and they represented important soil types in Indiana (Table 1).

TABLE 2.

Relation of height of corn 31 days after planting to rates of broadcast phosphorus and potassium fertilizer treatment. Fincastle and Russell soils, H. Byers Farm, Lafayette, Indiana, 1963.

Rates of K in Lbs. per A.	Rate of P in Lbs. per A.		
	0	52	105
		Inches	
0	13.7	—	—
149	12.8	19.1	20.7
299	14.8	18.7	18.1

Lsd at the 20% level = 1.7 inches
Lsd at the 5% level = 2.6 inches
Lsd at the 1% level = 3.5 inches

Height of corn increased 3.3 to 7.9 inches as phosphorus rates increased on the Fincastle and Russell soils location in 1963 (Table 2). There was no significant differences in height between the Fincastle soil (Replication I) and the Russell soil (Replications II and III).

Yields on the Fincastle replication were 11 to 12 bushels per acre higher than the yields on the two Russell replications. The probability was more than 99 to 1 that this difference was real and was not due to chance alone. Yields of corn grain were significantly increased 4.5 to 15.1 bushels per acre as rates of phosphorus fertilization increased in the same experiment (Table 3). There was also a trend toward higher phos-

TABLE 3.

Relation of yields of corn grain with 15.5 percent moisture to rates of broadcast phosphorus and potassium fertilizer treatment, Fincastle and Russell soils, H. Byers Farm, Lafayette, Indiana, 1963.

Rate of K in Lbs. per A.	Rate of P in Lbs. per A.		
	0	52	105
	Bu. per A.		
0	91.0	—	—
149	113.3	128.4	127.3
299	119.2	123.8	123.7

Lsd at the 20% level = 9.8 bu. per A.
Lsd at the 5% level = 13.8 bu. per A.
Lsd at the 1% level = 21.7 but. per A.

phorus content of the ear leaf of corn taken at silking as rates of phosphorus increased (Table 4). Where no phosphorus was applied, percent

TABLE 4.

Relation of chemical composition of the ear leaf of corn at silking to fertilizer treatment, Fincastle and Russell soils, H. Byers Farm, Lafayette, Indiana, 1963.

Lbs. per A. of		Percent Composition					Parts per Million			
P	K	N	P	K	Ca	Mg	Mn	B	Cn	Zn
0	0	2.68	0.20	1.86	0.67	0.35	158	18	17	50
0	299	2.85	.22	2.43	.56	.20	137	18	13	52
109	0	2.66	.24	1.44	.87	.41	172	17	13	39
109	299	2.91	.26	2.48	.62	.20	191	16	12	45
Low range		2.46-2.75	.16-.24	1.26-1.70	.11-.20	.11-20	16-19	2-3	2-5	11-20

phosphorus in the ear leaf was in the low range as defined by the Purdue Plant and Soil Anailysis Laboratory (4). The response to phosphorus was large for the first increment of fertilizer as might have been expected from the very low soil test value for phosphorus.

In the same experiment there was no increase in height of corn in relation to rates of potassium fertilization (Table 2), but there was a

significant increase in yield (Table 3). Where phosphorus was applied and potassium was not, corn ear leaf content of potassium was in the low range (Table 4). Evidently, soil potassium available to corn was not low enough to influence height 31 days after planting, but it did influence the plants later in the season.

After 1963, it was impossible to obtain additional data from this Fincastle and Russell soils experiment. After the death of the owner, H. Byers, the new owner would not lease the land for agricultural research purposes.

On the Martinsville and Russell soils location height of corn 46 days after planting was significantly increased as rates of both row and broadcast phosphorus increased (Table 5). Twenty pounds per acre of

TABLE 5.

Relation of height of corn 46 days after planting to rates of row and broadcast phosphorus fertilizer treatment, Martinsville and Russell soils, C. Gwin Farm, Lafayette, Indiana, 1964.

Broadcast P Lbs. per A.	Row Application of P in Lbs. per A.					
	0	5	10	20	30	40
			Inches			
0	44	52	55	56	57	56
60	49	56	58	58	—	—
120	56	—	—	—	—	—
300	—	—	—	—	—	60

Lsd at the 20% level = 3 inches
Lsd at the 5% level = 5 inches
Lsd at the 1% level = 7 inches

row phosphorus resulted in the same height of corn as 120 pounds per acre of broadcast P, or a 1 to 6 efficiency ratio. Drouth was so severe at this location in July and August, 1964, that yields ranged from 2 to 87 bushels per acre, and they were not significantly related to treatment. This great range in yields reflected a large difference in available soil moisture.

Height of corn 48 days after planting was significantly reduced at the high rates of broadcast potassium on the Martinsville and Russell soils location (Table 6). It is thought that high soluble salts in the soil and relatively dry soils reduced rate of growth in this drouthy season. Yields of corn grain were very low, ranging from 2 to 27 bushels per acre, and they were not significantly related to potassium treatment.

On both of these experiments on the Martinsville and Russell soils there was great variation in initial soil test values from individual plots. As a result of this variation and the yield variation, particularly in the phosphorus experiment, the location was discontinued.

TABLE 6.

Relation of height of corn 46 days after planting to rates of row and broadcast potassium fertilizer treatment, Martinsville and Russell soils, C. Gwin Farm, Lafayette, Indiana, 1964.

Broadcast K Lbs. per A.	Row Applications of K in Lbs. per A.					
	0	25	50	75	100	125
	Inches					
0	67	66	69	64	68	66
149	69	69	65	64	—	—
598	62	—	—	—	—	59

Lsd at the 20% level = 3 inches
Lsd at the 5% level = 5 inches
Lsd at the 1% level = 6 inches

On Crosby soil in a three-year period (1963-1965) height and yields of corn were significantly increased as phosphorus fertilization increased, but height and yields were not meaningfully related to potassium fertilization even though initial soil test levels for phosphorus and potassium were very low and low respectively (Tables 7 and 8). Analyses of the ear leaf

TABLE 7.

Relation of height of corn six weeks after planting to rates of broadcast phosphorus and potassium fertilizer treatment, Crosby soil, E. R. Brown Farm, Lafayette, Indiana, 1963-1965 inclusive.

Rate of K Applied in 1963 Lbs. per A.	Rate of P Applied in 1963 Lbs. per A.		
	0	66	131
	Inches		
0	31	—	—
149	28	37	39
299	31	36	41

Lsd at the 20% level = 3 inches
Lsd at the 5% level = 4 inches
Lsd at the 1% level = 5 inches

of the 1963 crop indicated that phosphorus was low when none was applied, and potassium was deficient (4) when none was applied (Table 9). Higher yield levels might have resulted in yield differences related to potassium fertilization. However, on this Crosby soil in this 1963-1965 period soil test levels did predict response to phosphorus fertilizer, but they did not predict response to potassium fertilizer.

TABLE 8.

Relation of yields of corn grain with 15.5 percent moisture to rates of broadcast phosphorus and potassium fertilizer treatment, Crosby soil, E. R. Brown Farm, Lafayette, Indiana, 1963-1965 inclusive.

Rate of K Applied in 1963 Lbs. per A.	Rate of P Applied in 1963 Lbs. per A.		
	0	66	131
		Bu. per A.	
0	44.0	—	—
149	38.9	70.1	78.4
299	47.2	78.5	94.0

Lsd at the 20% level = 17.2 bu. per A.
Lsd at the 5% level = 26.3 bu. per A.
Lsd at the 1% level = 35.0 bu. per A.

TABLE 9.

Relation of chemical composition of the ear leaf of corn at silking to fertilizer treatment, Crosby soil, E. R. Brown Farm, Lafayette, Indiana, 1963.

Fertilizer Treatment Lbs. per A. of		Percent Composition					Parts per Million			
P	K	N	P	K	Ca	Mg	Mn	B	Cn	Zn
0	0	2.64	.20	1.09	0.69	0.61	89	15	10	46
0	299	2.58	.18	1.83	0.56	0.34	118	17	9	52
135	0	2.68	.29	0.65	1.18	0.90	175	16	12	39
135	299	2.72	.27	1.90	0.68	0.39	132	14	9	34
Low range		2.46-2.75	.16-.24	1.26-1.70	.11-.20	.11-20	16-19	2-3	2-5	11-20
Deficiency range less than—		2.45	.15	1.25	0.10	0.10	15	2	2	10

Summary

Average yields of corn on one replication of a Fincastle soil were 11 more bushels per acre higher than those on two replications of a Russell soil of a fertilizer experiment. On this experiment and also on a similar experiment on Crosby soil, height of corn, yield of grain and phosphorus composition of corn ear leaves were increased as rates of phosphorus fertilization increased. On a third location on Russell and Martinsville soils, height of corn was increased, but yields were not increased in a

drouthy season, as rates of phosphorus fertilization increased. The initial phosphorus soil test levels of all three locations were low or very low.

Potassium fertilization increased yield and potassium composition of ear leaf of corn on the Fincastle and Russell soils location testing low in potassium. High rates of broadcast potassium fertilizer on a Martinsville and Russell soils location reduced corn height in a very dry year. On a Crosby soil there was no height or yield response of corn to potassium fertilization over a three-year period even though the initial soil test level for potassium was low.

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