Corn and Soil Responses to N, P, K, and Lime

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Introduction

The study was established in 1963 to determine (1) if acidification of soil from nitrogen (N) fertilization could be controlled in continuous corn with annual lime applications, (2) the amounts of phosphorus (P) and potassium (K) fertilizer and lime needed to maintain fertility, and (3) the nutrient balances that would develop and their effects on corn production.

Materials and Methods

P, K, and barn lime treatments were broadcast (applied by hand) in the fall each year. In 2003, dried water treatment lime sludge from the City of Des Moines (supplied by Kelderman Lime of Oskaloosa) was used instead of barn lime. Chisel plowing was used to incorporate fall-applied treatments. Nitrogen (N) treatments (urea) were broadcast (applied by hand) in April of 2004. The farm superintendent selected and planted hybrid corn in May. Herbicide was applied to all plots after planting. Before 2004, N applications had been missed for several years because of a labor shortage at the farm.

Results and Discussion

Excellent corn emergence resulted. Weeds were controlled throughout the growing season. Heavy, early-season rains caused some water to pond but there was no loss of plants. A three-row harvest strip in each 8-row plot was harvested. The combine operator collected corn weights and moisture content electronically. Corn ear samples were collected from rows adjacent to the harvest strip to be shelled. Grain quality was determined by the Iowa Grain Quality Initiative of the ISU Grain Quality Laboratory in Ames. Each plot was soil sampled in the fall of 2004 by combining six 3/4-in.-diameter by 6-in.-deep cores. These were dried, ground, and analyzed in Ames. Table 1 reports the soil-test results, and Table 2 reports the corn grain moisture, yield, and grain quality data. An annual barn lime application of 375 lb/acre/100 lb of N resulted in effective calcium carbonate equivalent (ECCE) deficiencies of less than 1,000 lb/acre after 41 years. Application of three times as much barn lime had no ECCE requirement and raised soil pH above 6.5, the desired pH. Soil-test P levels increased nearly 500% with a threefold increase from P fertilizer over the period. However, K soil test values increased only 50% with a threefold increase in K addition. The portion of extractable calcium increased with increasing barn lime additions. This probably reflects the fact that barn lime sources are usually calcitic. Corn yields were increased by the addition of N and P. At the lowest rates of N, yields were reduced by the greater K-application rate. This depression due to K became less as more N and barn lime were applied. Grain protein content increased with an increasing N rate. This study indicates that corn producers in northern Iowa who consider reducing N rates should examine their soil's K-test level before doing so. Soil tests for K greater than 100 ppm prevented achieving maximum yields at both 60 and 120 lb of N in this study. However, the producer who feeds grain to livestock might justify applying a somewhat higher N rate to ensure greater grain protein content in feed.

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Table 1. Mean soil test in 2004 resulting from annual N, P, K, and lime applications since 1963.

		Soil test results									
P	K	pH	P	K	ECCE	Ca:Mg	pH	P	K	ECCE[a]	Ca:Mg
lb/acre			ppm		lb/acre			ppm		lb/acre	
N=60		---------- 225 lb barn lime/acre ----------					---------- 675 lbs barn lime /acre ----------				
15	20	6.6	20	84	950	3.7	6.7	20	83	0	5.0
15	60	6.3	20	122	950	3.9	6.5	22	131	0	4.9
45	20	6.3	95	85	1050	3.8	6.7	100	96	0	4.5
45	60	6.0	85	127	1050	4.0	6.6	86	121	0	5.0
N=120		---------- 450 lb barn lime/acre ----------									
0	40	6.5	3	116	650	4.2					
30	0	6.4	58	68	650	4.3					
30	40	6.4	47	108	650	4.2					
30	80	6.1	51	146	950	4.6					
60	40	6.2	118	97	1300	4.4					
N=180		---------- 225 lb barn lime/acre ----------					---------- 675 lb barn lime /acre ----------				
15	20	5.8	10	70	3150	3.9	6.4	11	78	0	4.8
15	60	6.1	14	135	3500	4.0	6.3	6	108	650	5.0
45	20	5.9	107	79	3850	3.9	6.4	89	76	1050	5.1
45	60	5.7	99	118	3850	3.8	6.4	83	104	300	5.3

[a]Pounds of ECCE required to raise soil pH to 6.5.

Table 2. Average corn yield and composition in 2004 resulting from annual N, P, K, and lime since 1963.

P	K	Yield	Moist.	Protein	Oil	Starch	Yield	Moist.	Protein	Oil	Starch
lb/acre		bushels/acre	---------- percent ----------				bushels/acre	---------- percent ----------			
N=60		---------- 225 lb barn lime /acre ----------					---------- 675 lb barn lime /acre ----------				
15	20	103	17.9	6.0	3.7	62.4	115	16.8	5.8	3.7	62.4
15	60	96	17.8	5.9	3.5	62.5	116	19.6	5.9	3.7	62.4
45	20	120	18.7	5.9	3.6	62.4	119	17.7	6.1	3.9	62.0
45	60	96	17.8	5.8	3.8	62.4	83	17.3	5.7	3.7	62.4
N=120		---------- 450 lb barn lime/acre ----------									
0	40	108	18.2	7.7	3.4	61.4					
30	0	137	18.1	6.6	3.5	62.1					
30	40	135	17.2	6.5	3.6	62.1					
30	80	121	17.4	5.7	3.6	62.6					
60	40	142	17.2	6.4	3.6	62.1					
N=180		---------- 225 lb barn lime /acre ----------					---------- 675 lb barn lime /acre ----------				
15	20	167	19.1	7.5	3.6	61.3	158	18.0	7.5	3.5	61.4
15	60	164	17.2	7.2	3.6	61.5	158	17.6	7.1	3.5	61.5
45	20	158	18.2	6.8	3.6	61.9	169	17.7	7.1	3.4	61.7
45	60	162	18.3	6.3	3.7	62.1	180	16.7	7.0	3.6	61.7