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Corn and Soil Responses to N, P, K, and Lime in Continuous Corn Production

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Abstract

This experiment was established in 1963 to determine if 1) acidification of soil from nitrogen (N) fertilizer could be controlled in continuous corn with annual lime applications, 2) the amounts of phosphorus(P) and potassium (K) fertilizer needed to maintain fertility, and 3) the nutrient balances that would develop and their effects on corn production. The study used 25 treatments in an incomplete factorial design where all treatments were replicated two times.

Disciplines

Agricultural Science | Agriculture | Agronomy and Crop Sciences

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Introduction

This experiment was established in 1963 to determine if 1) acidification of soil from nitrogen (N) fertilizer could be controlled in continuous corn with annual lime applications, 2) the amounts of phosphorus (P) and potassium (K) fertilizer needed to maintain fertility, and 3) the nutrient balances that would develop and their effects on corn production. The study used 25 treatments in an incomplete factorial design where all treatments were replicated two times.

Material and Methods

P, K, and barn lime treatments were broadcast applied by hand each year. Beginning in 2003, 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. Urea-N treatments were broadcast applied by hand each crop year. The farm superintendent selected the hybrid corn variety and planted it in May. Herbicide was applied to all plots after planting. For several years before 2004, a uniform N application was applied because of a labor shortage at the farm.

Results and Discussion

Table 1 presents soil test results impacted by N and lime treatments. Soil pH declined with increasing N rate and increased with increasing lime rate. If a soil pH of 6.5 is considered appropriate, the continuous corn at the 120 and 180-lb N rates achieved it with 450 and 675 lb of lime, respectively. This is double the amount of pure calcium carbonate that is expected to neutralize the acidity released by nitrification of ammonium N to nitrate N. The importance of maintaining a target pH of 6.5 is demonstrated by the ammonium and nitrate-N measured. These variables increase as more N was applied, however greater conversion to nitrate occurred at the higher pH and more ammonium remained at greater concentrations at the lower pH.

Table 2 reports P and K soil test values as they responded to their rate of application and N rates. Lime rates had little measurable effect on extracted P and K. An annual P application of 15 lb maintained an optimum P value at the 180-lb N rate. At the 60-lb N rate, the P soil test value was double the optimum value. This reflects the diminished yield obtained with one-third as much N and hence, reduced P removal by grain harvest. Soil test values of K also reflected the impact of N on yield and hence quantities of K removed with harvested grain. Optimum K was maintained with an annual application of 60 lb when 180 lb of N was applied.

Table 3 presents grain moisture content, yield, and corn stalk tissue ammonium and nitrate N, inorganic P, and chloride (Cl) contents. The maximum yield of 180 bushels/acre was achieved with 240 lb of N. Yields were in the 170-bushel range where 45 lb of P was applied. The lime and K rates had minimal effects on yield. At the present time, only stalk nitrate N content is used to evaluate the sufficiency of N applied during the crop year. It is not used to evaluate other nutrients. An optimum nitrate N content is interpreted to be 750 to 1,000 mg/kg stalk tissue. None of the greater yielding treatments achieved this level of nitrate N. The impact of inadequate N on stalk tissue is seen in elevated P and Cl contents. We included Cl determinations because this element is acquired from 0-0-60 fertilizer, the K source used in this experiment.

Conclusions

The importance of having long-term fertility research has been demonstrated by this study. Simply stated, unless all nutrients are applied at appropriate rates to achieve optimal yields, P and K will accrue in the soil beyond concentrations needed by a corn crop. Soil testing provides a good means to determine if soil acidity is being controlled and P and K are at optimum values. Although lime was to be applied at a rate to annually neutralize soil acidity, neutralization was not accomplished. Unfortunately, samples of the barn lime were not analyzed over the years to determine their true neutralization value. Finally, additional research is needed to address P and Cl stalk tissue content relationships to nitrate N values that are used to determine N sufficiency in continuous corn production.

Acknowledgements

This year's study was carried out with assistance from the Northern Research Farm personnel.

Table 1. Soil test pH, electrical conductivity, ammonium and nitrate nitrogen responses to N and lime rates applied to continuous corn.

	Effective calcium carbonate, lb/acre									
N-rate	0	225	450	675	900	0	225	450	675	900
lb/acre	Soil sampled when corn plants were 1-ft tall									
	----- Ammonium nitrogen, mg/kg -----					---------- Nitrate nitrogen, mg/kg ----------				
0			5.9					3.5		
60		5.7		5.8			3.4		4.2	
120	7.9		6.3		6.9	6.9		11.9		15.1
180		9.2		6.9			33.8		21.1	
240			8.9					37.8		
	Soil sampled after harvest									
	---------------------- pH ----------------------					Electrical conductivity, deci-siemens/cm				
0			6.7					191		
60		6.2		6.9			178		228	
120	5.5		6.4		7.1	148		236		319
180		5.4		6.5			298		281	
240			5.7					339		

Table 2. Soil test P and K responses to N, P, and K applied to continuous corn.

	Annual N application, lb/acre						Annual N application, lb/acre				
P	0	60	120	180	240	K	0	60	120	180	240
lb/acre	-------- Soil test P, mg/kg -------					lb/acre	-------- Soil test K, mg/kg -------				
0			8			0			115		
15		36		18		20		153		126	
30	120		78		97	40	200		175		150
45		128		127		60		219		192	
60			154			80			219		

Table 3. Long-term continuous corn grain and stalk tissue responses to N, P, K, and lime.

Treatment applied annually				Grain		Stalk tissue			
N[a]	P[b]	K[c]	ECCE[d]	Moisture	Yield	NH_4-N[e]	NO_3-N[f]	P[g]	Cl[h]
---------- lb/acre ----------				percent	bu/ac	--------------- mg/kg ---------------			
0	30	40	450	19.0	54.4	55	14	2,332	501
60	15	20	225	18.4	54.9	73	13	1,776	915
60	15	20	675	18.8	64.9	64	10	1,753	777
60	15	60	225	18.2	39.4	95	14	1,886	656
60	15	60	675	18.0	39.4	61	19	2,132	1,551
60	45	20	225	17.9	56.7	59	31	2,272	1,098
60	45	20	675	18.5	63.7	47	12	2,355	581
60	45	60	225	18.6	44.2	64	12	2,391	1,259
60	45	60	675	17.9	53.6	44	14	2,367	1,146
120	0	40	450	18.3	105.0	134	288	107	211
120	30	0	450	18.0	149.2	42	12	667	717
120	30	40	0	17.5	100.6	46	13	1,088	1,267
120	30	40	450	18.2	165.1	172	100	635	236
120	30	40	900	18.4	154.0	59	41	881	1,239
120	30	80	450	18.2	101.4	42	12	1,871	537
120	60	40	450	18.1	163.4	44	14	1,064	1,548
180	15	20	225	18.6	141.8	236	302	147	493
180	15	20	675	18.3	156.6	316	239	151	188
180	15	60	225	19.0	157.1	99	512	135	195
180	15	60	675	18.0	155.5	263	1,506	145	807
180	45	20	225	18.2	171.5	105	427	176	284
180	45	20	675	18.0	178.0	52	30	256	1,626
180	45	60	225	18.2	174.2	65	319	303	536
180	45	60	675	18.1	176.5	101	190	265	1,473
240	30	40	450	18.5	180.2	117	337	249	1,031

[a]Nitrogen from urea.
[b]Phosphorus from 0-44-0.
[c]Potassium from 0-0-60.
[d]Effective calcium carbonate equivalent.
[e]Ammonium nitrogen.
[f]Nitrate nitrogen.
[g]Inorganic phosphorus.
[h]Chloride.