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Liming, Nitrogen and Manure Rates for Continuous Corn

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Abstract
Producers faced with economic and environmental concerns should know about the benefits of lime, nitrogen (N) and manure applications on acid soils in southwest Iowa. At the Armstrong Farm, an area of Marshall silty clay loam was identified that possessed an extremely acidic surface soil. In 1995, a liming study was initiated in what had been, and continues to be, a continuous corn production system. The goals of this experiment are to determine corn crop and soil responses to liming, N and manure rates.

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Introduction

Producers faced with economic and environmental concerns should know about the benefits of lime, nitrogen (N) and manure applications on acid soils in southwest Iowa. At the Armstrong Farm, an area of Marshall silty clay loam was identified that possessed an extremely acidic surface soil. In 1995, a liming study was initiated in what had been, and continues to be, a continuous corn production system. The goals of this experiment are to determine corn crop and soil responses to liming, N and manure rates.

Materials and Methods

In 1994, soil pHs from the 0 to 6-in. depth at the site were as low as 4.1. Buffer pH soil tests determined a lime requirement of seven and one-half tons per acre of effective calcium carbonate equivalent (ECCE) to raise the soil pH to 6.5. Fifteen tons per acre of ag-lime from the Atlantic quarry would supply the ECCE needed. In April 1995, ag-lime application rates of 0, 1.67, 5, 15 and 45 tons per acre were applied to reach target acidity levels of a less than 5.0 check, 5.5, 6.0, 6.5, and 7.0, respectively. Nitrogen treatments were initiated in 1996. Nitrogen application practices consisted of 1. broadcasting urea (BCU), 2. banding urea 6 in. deep (BU), 3. banding urea mixed with pelletal limestone (BUL), and 4. broadcasting liquid swine manure (manure). Rates of 45, 90, 135, and 180 lb N per acre were applied by each application practice. Urea and pelletal limestone were combined to supply 185 lb of ECCE per 100 pounds of N. Manure obtained from a confinement pit was broadcast applied at rates of 1,000, 2,000, 3,000 and 4,000 gallons per acre to supply N equivalent to those rates applied with urea. Each plot receiving an N-treatment is eight rows wide. All treatments are replicated four times; there are 320 plots in the experiment.

Compaction that resulted from repeated lime application trips was initially treated by subsoil tillage 16 to 18 inches deep in the fall of 1995. Summertime observations during the following years suggested that the compaction problem might not have been adequately addressed with one subsoil tillage operation. Subsoil tillage was conducted again after harvests in 1998 and 1999.

Corn was harvested from the middle four rows of each plot. In each plot, eight corn plants were randomly selected adjacent to the harvested rows where an 8-in. cornstalk segment starting at six inches above the soil and the ear from the same plant were collected. The ears were shelled, and the ISU Grain Quality Laboratory supported by the Iowa Grain Quality Initiative analyzed the grain. Cornstalk samples were dried, ground and analyzed for anion nutrients: chloride (Cl), nitrate-N, inorganic phosphorus (P), and sulfate-sulfur; basic cations: calcium (Ca), potassium (K), magnesium (Mg), and sodium (Na); and micro-nutrients: copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn).

Results and Discussion

Soil test data obtained from 1995 through 1999 were determined from late-spring Nitrate-N soil test samples collected from 0 to 10 inches deep when the corn was about a foot tall. Soil test phosphorous (STP) and soil pH response to lime and N are shown in Table 1. The BCU treatments supplied no phosphorus (P), and its test valued declined. Manure supplied both N and P, and the latter increased with manure application. The greatest STP change occurs after the first manure application in 1996. Ag-lime has decreased soil acidity as noted by the increase in soil pH between 1995 and 1999. Neither BCU nor manure treatments affected soil acidity. The greatest pH change occurred in the 45-ton lime rate. Responses to ag-lime are slow to occur, which is expected.

Data showing corn grain yields and grain composition for 1999 are summarized in Table 2 (the corn crop was destroyed by hail in 2000.) Grain yield tends to increase with higher N rates; however, the 180 lb per acre N rate did not always produce the greatest yield. Grain protein tends to increase with higher N rates; the highest protein is found in the highest N rate. Manure application tends to reduce the protein content over all lime and N treatments. There is little difference found in the grain oil and starch contents.

Cornstalk analysis describes the status of various nutrients remaining after the corn grain matured and sap flow has ceased. Cornstalk nitrate and P are summarized in Table 3 by lime and N rates. Nitrate-N values tend to increase with higher nitrogen rates and tend to decrease with higher lime rates. Cornstalk P tends to decrease with higher N rates; the P observations in the manure application practice tend to be greater than the BCU or banded urea practices. Table 3 summarizes the cornstalk Cl, nitrate-N, P, and K for BCU and manure practices and N rate. The manure application practice contains more Cl, P and K, whereas it has less nitrate than the broadcast application practice. Soil and cornstalk relationships generally showed that increased soil pH decreased micronutrient availability in soil and the content in cornstalks.

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Table 1. Soil Test P and pH for Armstrong Farm Liming and N Experiment.

	Agricultural Limestone Applied in 1995, tons per acre									
Year	0	1.7	5	15	45	0	1.7	5	15	45
	Urea N Broadcast Applied					Manure N Broadcast Applied				
	Soil Test P, parts per million									
1999	22	20	22	23	23	38	35	32	43	45
1998	23	22	20	26	29	36	40	34	42	44
1997	20	19	18	20	23	33	36	30	33	35
1996	28	28	26	31	28	32	35	32	40	39
1995	26	24	24	26	25	24	23	22	24	24
	Soil pH									
1999	5.4	5.8	5.8	6.5	6.9	5.4	5.7	5.8	6.4	6.9
1998	5.3	5.8	5.7	6.1	6.8	5.4	5.9	5.8	6.4	6.9
1997	4.8	5.2	5.3	5.7	6.2	4.8	5.3	5.4	5.8	6.4

Table 2. 1999 Armstrong Farm Lime and N Experiment Grain Yield and Protein Content.

	Agricultural Limestone Applied, tons per acre									
N per acre	0	1.7	5	15	45	0	1.7	5	15	45
lbs.	Urea N Broadcast Applied									
	Grain Yield, bushels per acre					Grain Protein Content, percent				
45	135	125	117	119	126	6.4	5.8	5.9	5.8	6.2
90	139	153	130	148	145	6.7	6.6	6.4	6.6	6.1
135	157	161	156	170	155	7.0	7.1	7.0	7.1	7.1
180	173	157	164	158	173	7.4	7.5	7.4	7.5	7.2
	Manure N									
45	134	136	138	144	132	6.0	5.5	5.7	5.8	5.6
90	151	155	151	145	148	6.2	6.1	5.8	5.9	5.9
135	165	162	164	169	163	6.9	6.4	6.5	6.5	6.7
180	178	180	167	178	169	7.2	6.9	6.7	6.6	6.8

Table 3. Cornstalk Cl, Nitrate-N, Inorganic P and K Contents.

N per acre	Broadcast	Manure	Broadcast	Manure
lbs.	Cl, ppm		Inorganic P, ppm	
45	128	508	420	798
90	180	962	344	700
135	91	1,555	106	235
180	92	2,796	63	413
	NO_3-N, ppm		K, percent	
45	192	10	1.32	1.49
90	303	22	1.30	1.63
135	1,993	264	1.82	1.54
180	3,593	2,366	1.63	2.00