

High Rates of Urea Fertilizer for Corn (*Zea mays* L.) on Two Soils, 1969-1971¹

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Abstract

Five rates of nitrogen from urea with accompanying rates of agricultural limestone were compared for continuous corn on Fincastle silt loam soil and on Chalmers silty clay loam soil. The effects of the urea were similar in both soils, but they were more pronounced on the Fincastle soil which was lower in both organic matter and in cation exchange capacity. In 1969 on the Fincastle soil, the highest rate of urea furnishing 1344 kilograms per hectare of nitrogen, when applied the day before planting, reduced stands of corn to 32 per cent and yields of corn grain to 37 per cent of those which received 336 kilograms per hectare of nitrogen. In 1970, there was no stand, vegetative growth or meaningful grain yield reductions when the same high rates of fertilizer were plowed under on the same plots in November prior to seeding in May. In 1971, soluble salts in the Fincastle soil were more than doubled, height of plants was reduced 20 per cent, and soil pH was reduced 0.9 unit with the 1344 kilograms per hectare rate of nitrogen as compared with the 336 kilograms per hectare rate of nitrogen.

Introduction

Powell and Webb (3) found that in the third year of continuous corn, yields began to decrease above 336 kg per ha (300 lbs per A) or 448 kg per ha (400 lbs per A) of nitrogen. They attributed this reduction to accumulation of salts and to decreases in soil pH. The purpose of this research, which is similar to that of Powell and Webb, is to compare high rates of N for continuous corn.

Methods

Two soil areas approximately 1 km (0.6 mile) apart were selected on the Purdue University Agronomy Farm. The Chalmers silty loam, classed as a Typic Arguauquoll, had been well fertilized and limed, as well as tile drained, and had been cropped to corn and soybeans (*Glycine max* L.) for several years. The plow layer had a cation exchange capacity of 32.5 meq per 100 g of soil, contained 4.4% organic matter, had 185 parts pp 2m of Bray No. 1 phosphorus (P) and had 675 pp 2m of potassium (K) as determined by the Purdue Soil Testing Laboratory. Soluble salts were low with a specific conductance of 19×10^{-5} mhos. This area is depressional. The other soil, a Fincastle silt loam, is classed as a Aeric Ochraqualf. It had received moderate rates of fertilization, had been well limed, and had been cropped to continuous corn for several years. Cation exchange capacity of the plow layer was 16.3 meq per 100 g of soil, and the organic matter content was 2.3%. It had 100 pp 2m of Bray No. 1 phosphorus (P) and 285 pp 2m of available potassium (K). Soluble salts were low with a K value of 16×10^{-5} mhos. Tile drainage was inferior to that in the

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Chalmers soil. Land leveling was used on the Fincastle soil prior to the initiation of this experiment to make the 2-4% slopes more nearly uniform.

The plot layout was a randomized complete block design with four replications of five treatments on each soil. Treatments were no N and four rates of N from fertilizer grade urea (45%) and rates of limestone as shown in Table 1. Soil samples from all plots were taken in May before applying treatments and in August of 1969, 1970 and 1971. Lime requirement was determined by use of the Shoemaker, McLean and Pratt buffer (4). Soil pH was determined using a 1:1 soil to water ratio and a Corning glass electrode pH meter. The agricultural limestone from the Delphi Limestone Company in 1969 had an average of 36% of the particles passing through a 60-mesh sieve and 95% through an 8-mesh sieve. The 1970 limestone from the Newton County Stone Company had 38% passing through a 60-mesh sieve and 95% through an 8-mesh sieve. The urea was broadcast one day before planting for the 1969 crop and in the previous

TABLE 1. Relation of rates of urea fertilizer and limestone application to soil pH, soluble salts, and nitrate nitrogen on two soils, 1969-71.

Kg/ha of N Applied Annually	Soil pH			M.Tons/ha Limestone Added		Soluble Salts Specific Conductance K (Mhos x 10 ⁻⁵)			Nitrates ppm
	5-28-69	8-13-69	8-3-71	'69	'70	8-13-69	6-29-71	8-3-71	6-20-71
Fincastle silt loam									
0	6.1	6.1	6.4	4.5	4.5	18	15	20	1
168	6.2	6.1	6.4	4.5	4.5	20	21	....	1
336	6.2	5.9	6.2	9.0	6.1	26	36	....	12
672	6.2	5.6	5.7	6.7	7.2	55	62	....	35
1,344	6.1	5.4	5.3	9.0	8.1	115	99	78	88
LSD 05 for rates	Not Sig.	.2	0.3			....	12	yes ¹	13
Average	6.1	5.8	6.0			47	47	49	
Chalmers silty clay loam									
0	6.4	6.5	6.5	0	0	15		16	
168	6.6	6.5	6.6	0	0	22		....
336	6.7	6.5	6.6	0	0	45		....
672	6.5	6.4	6.3	4.5	2.7	68		....
1,334	6.4	5.9	5.9	6.7	5.2	115		36	
LSD 05 for rates	0.3	Not Sig.	0.5			....		yes	
Average	6.5	6.4	6.4			53		26	
LSD 05 for soils	Yes ²	yes ²	Not Sig.			....		yes ²	

¹Yes means averages for the different rates of N are significantly different from each other at the stated or greater probability.

²Yes means averages for the two soils are significantly different from each other at the stated or greater probability.

November for the 1970 and 1971 crops. In 1969 all fertilizer was broadcast after plowing disked, or field cultivated for incorporation. For the 1970 and 1971 crops broadcast limestone and fertilizers were plowed under in the previous November, and field cultivation and spike tooth harrowing were used for spring preparation for planting. In all years the urea was applied last just prior to disking or plowing. In 1969, 1,190 kg per ha (1,065 lbs per A) of 0-11-21 (percentages of total N, available P, and available K) were applied to all plots. For the 1970 and 1971 crops 975 kg per ha (870 pounds per acre) of 0-11-21 fertilizer were applied each year to all plots.

Broadcast aldrin was incorporated into the soil in 1969 to control soil insects. The corn hybrid, DeKalb XL-45, was planted May 29, 1969, and Pioneer 3369A was planted May 8, 1970 and May 4, 1971. Average final stands were 43,000 plants per ha (17,400 plants per A) in 1969, 54,000 plants per ha (21,860 per A) in 1970, and 59,000 plants per ha (23,900 per A) in 1971. In 1970 corn was planted at a high rate and hand thinned to an exact population per row. Stand counts were taken in 1970 prior to thinning. In 1969 and in 1971 no hand thinning was done. Atrazine (Aatrex) and Lasso were used as broadcast pre-emergence herbicides. Cultivation was also used for weed control. Corn was planted in 76 cm (30 inch) rows in plots 18.3 m (60 feet) long and 4 corn rows wide. Hand harvest areas were 7.9 m (26 feet) long and the 2 center rows were used. Moisture percentages in the grain and tables for converting ear corn weights to shelled corn were used to calculate grain yields. Yields are reported on a 15.5% moisture in shelled corn basis.

Corn ear leaf samples were analyzed for plant nutrients by the Growth Sciences Center of the International Mineral Chemical Corporation, Libertyville, Illinois.

Results and Discussion

The use of the highest rate of urea (1,344 kg per ha or 1,200 lbs per A) in 1969, resulted in a decline of 0.7 pH unit in Fincastle soil and 0.5 pH unit in Chalmers soil (Table 1). In 1971, the soil pH was 5.3 on this treatment on the Fincastle soil. According to Barber (1), limestones having low percentage of particles passing through a 60-mesh sieve are not likely to be efficient in acting rapidly to correct soil acidity. With 36 to 38% passing a 60-mesh sieve, these limestones were apparently too coarse to completely correct acidity in time between application and pH measurement.

Soluble salts in both soils were higher as rates of nitrogen increased. This was true in both 1969 and in 1971 (Table 1). Soluble salts were not determined in 1970 when no growth irregularities were observed. In 1969 differences in numbers of plants per plot and yield related to treatment were observed (Table 2) even with 4.5 cm of rain in the 10 days following planting. In 1969 the stand (number of plants per plot) on the 1,344 kg per ha rate of nitrogen from urea was reduced to 33% and yields of corn grain were reduced to 37% of those which received 336 kg per ha of nitrogen. This reduction in stand cannot be attributed entirely to salt effect.

Hunter and Rosenau (2) found that in closed urea-soil systems, urea-soil mixtures out of contact with germinating corn seeds released gaseous ammonia into the atmosphere, and the ammonia inhibited germination and affected seedling development of corn. Similar effects were noted when corn was seeded in soils saturated with ammonium ion to the extent of 32% or more. The 1,336 kg per ha rate of N used herein would, if carefully mixed and all the ammonia (from urea) were absorbed on the exchange sites, saturate 80% of the cation exchange capacity of Fincastle soil and 40% of the exchange capacity of Chalmers soil. Highly significant reductions in stand were found at this rate of N on both soils. However, at the 672 kg per ha (600 lbs per A) rate of N, stand was reduced significantly only on the Fincastle soil. In all years N deficiency symptoms were observed on both soils in the no nitrogen treatment. In 1971, a year of high corn yields, these symptoms of N deficiency were severe. The significantly lower grain yield on both soils of the 672 kg per ha rate of N than the 1,344 kg per ha of N in 1970 was not thought to be meaningful because the 336 kg per ha treatment was also higher yielding. The general

TABLE 2. *Relation of rates of urea fertilizer application to plant population, leaf height, and yield of corn on two soils, 1969-1971.*

Kg/ha of N Applied Annually	1969		1970		1971	
	Plants per Plot (7.92 m x 1.52 m)	Grain Yield (kg/ha)	Maximum Leaf Height (6-26-70 cm)	Grain Yield (kg/ha)	Maximum Leaf Height (6-23-71 cm)	Grain Yield (kg/ha)
Fincastle silt loam						
0	61	7,500	81	4,450	113	1,470
168	63	8,540	100	8,950	115	9,240
336	65	8,140	97	8,840	116	10,020
672	48	6,120	99	8,220	91	8,490
1,344	21	3,020	100	9,010	92	9,250
LSD 05 for rates	10	1,120	14	680	18	1,610
Average	52	6,660	95	7,900	105	7,690
Chalmers silty clay loam						
0	59	7,500	114	6,379	140	2,990
168	51	9,350	128	9,615	181	11,880
336	59	9,040	138	9,697	181	12,450
672	55	8,710	143	9,044	175	12,720
1,334	31	5,310	148	9,941	165	12,690
LSD 05 for rates	9	1,690	10	730	7	2,110
Average	53	7,980	134	8,944	168	10,550
LSD 05 for soils	Not Sig.	yes ¹	yes ¹	yes ¹	yes ¹	yes

¹Yes means averages for the two soils are significantly different from each other at the stated or greater probability.

trend in yield was very slightly higher in rates above none. This trend was the result of heavier ears with the higher rates of N.

In 1971, even though grain yields were not reduced significantly, maximum leaf heights were reduced significantly at the two highest rates of N in the Fincastle soil and at the highest rate on Chalmers soil (Table 2). Total soluble salts and also nitrates were high in these two highest treatment rates of N from urea on Fincastle soil. Soluble salts were not as high on the Chalmers as on the Fincastle soil at the highest rate of N in 1971. High soluble salts in soil probably contributed to the reduced rate of growth of corn in the highest treatments on the Fincastle soil. Height of plants was reduced 20% on the Fincastle soil and to only 9% on the Chalmers soil in 1971. Germination and stand were not measurably affected by high rates of N, and neither were grain yields.

Plant analysis on corn ear leaves indicated that contents of manganese (Mn) increased from 4 to 15 times as rates of nitrogen were increased from 0 to 1,344 kg per ha (Table 3). This increased uptake of Mn was associated with a lower soil pH. Content of Mn in the ear leaves was 2 to 3 times as high from the 168 kg per ha rate of N on Fincastle soil as from the same rate of Chalmers soil. Soil Mn determinations were not made.

TABLE 3. *Relation of soil types and rates of nitrogen to manganese in corn ear leaves on two soils, 1970-71.*

Kg/ha of N Applied Annually	Part per Million of Manganese			
	Fincastle silt loam		Chalmers silty clay loam	
	1970	1971	1970	1971
0	35	33	14	<10
168	52	46	16	17
336	53	48	20	22
672	94	91	34	37
1,344	149	186	91	77
LSD 05	38	66	12	Not possible
LSD 01	64	93	19	Not possible

In conclusion, high rates of urea (672 or more kg per ha of N) incorporated into the plow layer of soil just before planting can reduce germination and yield of corn. Also, high rates of urea can cause soil pH to decline as much as 0.7 of one pH unit in one cropping season. After three applications of high rates of urea and two applications of limestone in three cropping years, soluble salts can become high enough to contribute to reduced maximum leaf height of corn in late June particularly on the low exchange capacity and low organic matter Fincastle soil.

Literature Cited

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