High Rates of Residual Nitrogen Fertilizer Change Corn Leaf Composition and Yields

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Introduction

Residual N is important because of energy conservation and possible control of pollution. Donohue et al. (3) found carryover the first year at rates greater than 84 kg N/ha for orchard grass *(Dactylis Glomerata)*. However, in the second residual year N carryover was observed at only the 672 and 1,344 kg N/ha rates. White, Dumenil, and Pesek (7) found, using oats as the test crop, that carryover N from a previously fertilized corn crop varied from insignificant amounts to 49% of that applied on the previous corn crop. Barber (1) found that carryover N for corn amounted to about one-third of the previous two year's applications on Raub silt loam soil.

The purpose of this experiment was to determine the influence of high rates of residual nitrogen fertilizer on corn (*Zea mays* L.) leaf composition and yields on two important Indiana soils.

Materials and Methods

Corn was grown on two soils which had received varying rates of N and limestone in an earlier experiment reported by Stivers (5). The soils were 1 km apart on the Purdue Agronomy Farm. The plots were arranged in a randomized complete block design of four replications of five annual rates of N-O, 168, 336, 672 and 1,344 kg N/ha 1969-1972—on each of two soils, a Fincastle silt loam classed as an Aeric Ochraqualf and on a Chalmers silty clay loam classed as a Typic Argiaquoll. The form of N applied was urea. Soil samples were taken in July, 1972. The plow layer of the Fincastle silt loam soil had an average soil pH of 6.5. The range in soil pH was from 6.8 with the no N treatment to 6.2 with 1,344 kg N/ha. Bray No. 1 P averaged 72 ppm in this soil. There was no apparent relation to N treatment. Quick-test exchangeable K averaged 151 ppm, and there was no relation to N treatment. Cation exchange capacity was 16.3 meq/100 g of soil, and the average organic matter (Walkley-Black procedure) percent was 2.3. Agricultural ground limestone had been applied 1969-1971 at rates that increased as rates of N increased, with 9 mt/ha on the no N treatment, to 27.6 mt/ha on the 1,344 kg N/ha treatment. No more limestone was applied during 1972-1974.

Chalmers silty clay loam had an average soil pH of 6.4. The range in pH was from 6.7 with no N to 6.1 with 1,344 kg N/ha. Bray No. 1 P in this soil averaged 106 ppm with no relationship to N treatment. Quick-test exchangeable K averaged 275 ppm and had no apparent relation to N treatment. Cation exchange capacity was 32.5 meg/100g soil, and average organic matter content was 4.4 percent. No agricultural ground limestone had been applied 1969-1971 on the no N, 168 kg/ha

and the 336 kg N/ha treatments on this soil. However, 7.2 mt/ha of limestone had been applied on the 672 kg N/ha treatment and 17.3 mt/ha of limestone had been applied on the 1,344 kg N/ha treatment. Limestone was applied to keep soil pH above 6.0. No limestone was applied on this soil in 1972-1973.

During the winter of 1972-1973, 112 kg/ha of P_2O_5 and the same amount of K_2O fertilizer was broadcast on each of the two soil areas before plowing. In April 1974, 156 kg/ha of K_2O fertilizer and 6.9 kg/ha of fertilizer borate containing 20.2 percent B were broadcast on all plots of the Fincastle soil which was plowed in late April the same year.

An insecticide was applied in 1972 for soil corn insect control, Pioneer 3369A hybrid corn was planted on both soil sites on May 4, 1973, and on the Fincastle site on May 7, 1974. Only the Fincastle soil site was used in 1974. Final plant populations were approximately 58,000 plants/ha in both years of the residual study. Herbicides and cultivation were used for weed control.

Corn ears were hand harvested in both years. Harvest areas were 7.9 m long and two 76-cm rows wide in both 1973 and in 1974. Moisture percentages in the grain and Brunson's (2) tables were used to convert ear corn weights to shelled corn with 15.5% moisture. Both grain yields and composition of corn ear leaves at tasseling were taken from the same two of four replications at each soil site. Two replications were used because of insufficient funds for plant analysis of more replications. Corn leaf samples (eight or more leaves per sample) were taken at the mid-silk stage, dried, and then ground in a stainless steel mill to pass through 1 mm openings. The leaf samples were analyzed by International Minerals and Chemical Corporation for all nutrient elements except N. Percent N was determined by A. J. Ohlrogge, Purdue University. An emission spectrograph was used for determining P, K, Ca, Mg, Mn, Zn, and Fe in the leaf tissue. A kjeldahl procedure was used for total N.

Statistical Methods used are described by Snedecor and Cochran (4).

RESULTS AND DISCUSSION

Nitrogen, Ca, Mn, and Fe concentrations in corn ear leaves, and corn grain yields increased significantly, ($p < 0.05$) on both Chalmers and Fincastle soils as rates of N applied 18 months previously increased from none to 1,344 kg/ha (Table 1). On Fincastle soil, ear leaf concentrations of P, K, Mg, and Zn also increased as rates of N increased. The highest significant ($p < 0.01$) correlation coefficient of leaf nutrient concentration with yield on both soils was with N. This was +0.93 on the Chalmers soil and +0.97 on the Fincastle soil. Nitrogen concentration was significantly correlated with concentrations of Ca, Mn, and Fe in leaves from the Chalmers soil. On the Fincastle soil, N concentration was also significantly correlated with P, K, Mg and Zn concentrations in corn leaves grown in this first residual N year.

Increases in concentration of Mn, Fe, P, K, and Zn in the corn leaves in this experiment with increasing rates of N are thought to be

due to their increasing availability in the soil where more hydrogen ions were released particularly in localized soil areas where urea granules were applied and roots absorbed nutrients. The lower soil pH values associated with the higher rates of N support this belief. Had soil tests for Mn, Zn, and Fe been run, it is believed that test values would have been greater at the lower soil pH values. However, there was no apparent relationship between N treatment of soil and soil tests for either available P or K just prior to the start of this experiment. Walker and Peck (6) although working with a lower maximum rate of N (358 kg N/ha), found that, in most cases, there was no increase in either Ca or Mg in corn leaves as rates of N increased. They also found increases in concentrations of N, P, K, Mn, and Zn, and corn yields as rates of N applied to the soil increased.

The change in N concentration from 1.10 percent with no N to 2.86 percent with the 1,344 kg N/ha rate on Fincastle soil was much greater than the 1.67 percent with no N to 2.68 percent N with the 1,344 kg N/ha rate on Chalmers soil (Table 1). The yield change from 232 kg/ha with no N to 10,255 kg/ha with 1,344 kg N/ha was greater on Fincastle than the corresponding yield change from 3,362 kg/ha with no N to 9,032 kg/ha with the 1,344 kg N/ha treatment on Chalmers soil. The higher percentage of organic matter, 4.4 percent in Chalmers soil as compared to 2.3 percent in Fincastle soil, no doubt contributed to higher grain yields on the no N treatment of the Chalmers soil.

In the second residual cropping year 30 months after N application on Fincastle soil, N concentrations in ear leaves from the 1,344 kg N/ha rate were 1.99 percent as compared to 1.15 percent with no N, and the difference between the two was significant (Table 2). Percentages of Ca, Mg, Mn, and Fe were positively and significantly ($p < 0.01$ correlated with N concentration in ear leaves. The correlation between yield and percentage of N in leaves was $+0.91$ ($p < 0.01$). Calcium and Fe, as well as N, were significantly and positively correlated with yield.

Increases in Ca and Mg concentration were positively correlated with increases in percentage of N in corn leaves grown on the Fincastle soil in both years (Tables 1 & 2). Percentages of N in the corn leaves significantly ($p < 0.05$) increased as previously applied rates of N increased. With increasing rates of N previously applied, increasing rates of agricultural ground limestone had been applied to bring soil pH above 6.0. Hence, the increasing concentrations of Ca and Mg in the corn leaves on the Fincastle soil were probably due to their greater availability in the soil. In the leaves from the Chalmers soil, Ca concentration increased as the three lower rates of N increased even though no limestone was applied in 1969-1972.

Yields of corn grain increased ($p < 0.05$) from 1,251 kg/ha with no N to 8,295 kg/ha with 1,344 kg N/ha in the second residual year (Table 2). However, many leaves had visual N deficiency symptoms even at the 1,344 kg N/ha rate.

TABLE 1. *Composition of corn ear leaves and yield of corngrain in relation to N rates in the first residual year, 1973.*

Annual rate of N 1969-1972	N	P	K	Ca	Mg	Mn	Zn	Fe	Grain Yield
kg N/ha	%					ppm			kg/ha
	Chalmers silty clay loam 1973								
0	1.67	0.30	1.32	0.39	0.24	15	15	57	3,362
168	1.66	0.28	1.40	0.40	0.25	19	14	54	4,259
336	1.92	0.32	1.44	0.46	0.26	22	15	65	4,403
672	1.91	0.28	1.33	0.49	0.28	17	12	70	6,222
1,344	2.68	0.33	1.47	0.48	0.28	33	18	81	9,032
LSD 0.05	0.44	NS	NS	0.05	NS	11	NS	14	2,155
r[1] with % N	—	+0.50	+0.41	+0.66*	+0.58	+0.75*	+0.43	+0.91**	+0.93**
r[1] with yield	+0.93**	+0.24	+0.35	+0.75*	+0.64*	+0.69*	+0.27	+0.89**	—
	Fincastle silt loam 1973								
0	1.10	0.22	1.17	0.32	0.25	22	13	39	232
168	1.19	0.25	1.21	0.32	0.25	29	13	42	1,869
336	2.39	0.29	1.47	0.47	0.30	51	18	75	8,172
672	2.63	0.32	1.56	0.53	0.32	57	20	91	8,524
1,344	2.86	0.35	1.56	0.58	0.35	103	24	89	10,255
LSD 0.05	0.72	0.06	0.21	0.08	0.11	15	2	16	2,629
r[1] with % N	—	+0.95**	+0.92**	+0.94**	+0.92**	+ 0.85**	+0.94**	+0.98**	+0.97**
r[1] with yield	+0.97**	+0.92**	+0.93**	+0.94**	+0.91**	+0.84**	+0.90**	+0.96**	—

[1] r Correlation coefficient.

* Significant difference at the 0.05 level.

** Significant difference at the 0.01 level.

TABLE 2. *Composition of corn ear leaves and yield of corn grain in relation to N rates in the second residual year, 1974.*

Annual rate of N 1969-1972	N	P	K	Ca	Mg	Mn	Zn	Fe	Grain Yield
kg N/ha	%					ppm			kg/ha
	Fincastle silt loam 1974								
0	1.15	0.20	1.56	0.38	0.29	24	19	57	1,251
168	1.36	0.19	1.54	0.40	0.29	42	18	62	1,778
336	1.48	0.19	1.50	0.43	0.30	39	19	67	3,108
672	1.69	0.22	1.55	0.49	0.30	44	20	68	4,362
1,344	1.99	0.22	1.59	0.53	0.33	47	21	74	8,295
LSD 0.05	0.45	NS	NS	NS	NS	NS	NS	NS	2,393
r[1] with % N	——	+0.41	+0.28	+0.92**	+0.76*	+0.79**	+0.16	+0.84**	+0.91**
r[1] with yield	+0.91**	+0.38	+0.23	+0.86**	+0.62	+0.50	+0.46	+0.64*	——

[1] r Correlation coefficient.

* Significant difference at the 0.05 level.

** Significant difference at the 0.01 level.

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