Effects of

ZINC FERTILIZER ON CORN YIELD

in Southeastern North Dakota

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Zinc deficiency symptoms have been observed in numerous corn fields in southeastern North Dakota in the past several years. Most often the affected crop was on coarse to moderately coarse-textured soil, but deficiency symptoms were noted also on corn grown on some fine-textured soils, especially if the soil was calcareous (limy) to or near the surface. The most severe cases of deficiency were observed on calcareous coarse-textured soils. In trials conducted at six locations over a period of two years, zinc fertilizer increased corn grain yields in three of four cases when yields exceeded 100 bushels an acre.

Hoyman (5) was the first to report yield increases from zinc fertilizer in North Dakota; foliar application of a zinc sulfate solution increased the yield of Irish Cobbler potatoes grown on a Bearden fine sandy loam in 1949. Grunes et al. (4) increased yields of Pontiac potatoes and Nodak 301 corn in 1954 with soil application of zinc sulfate on Gardena loam from which one foot of surface soil had been removed in leveling in preparation for gravity irrigation. Removal of one foot of the soil had exposed a high lime subsoil.

In 1963, Cotrufo et al. (3) found that various soil-applied zinc materials had no effect on yield of A or B-sized Pontiac potato tubers grown on Bearden clay loam and Glyndon silt loam. Studies[a] of the effect of soil application of zinc on flaxseed yield by Zubriski in 1963 showed that flaxseed yields were increased by phosphatic fertilizer in the presence of soil-applied zinc fertilizer on Bearden silt loam, but without zinc fertilizer, yields were decreased by phosphate fertilizer. In trials by Young in 1949 and by Bauer in 1966 flaxseed yield was not affected by zinc fertilizer. Bauer et al. (2) also reported that zinc together with other micronutrients had no effect on yields of wheat.

Six trials were conducted in this study to determine the effect of zinc fertilizer alone and in combination with phosphorus fertilizer on corn grain yield.

METHODS

The six trials were conducted in Richland County, three each in 1965 and 1966. The cooperator, soil type, planting and harvest dates, row spacing, plant populations, and some soil chemical characteristics are shown in Table 1.

A nitrogen-phosphorus-potassium containing fertilizer was broadcast and incorporated into the soil at each site prior to planting. The amounts of plant nutrients broadcast are shown in Table 2.

The experimental design in both years was a split plot with main plots of four replications. In 1965, two rates of phosphorus (8.8 and 17.6 pounds

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a Unpublished data

Table 1. Cooperator, soil type, planting and harvest dates, row spacing, plant population, and some soil chemical characteristics at sites of field trials.

	Cooperator					
	Edward Kummer	Adolph Ista	Selmer Jordheim	Raymond Kummer	Adolph Ista	Wayne Haverland
Year	1965	1965	1965	1966	1966	1966
Soil type	Glyndon very fine sandy loam	Hamar loamy fine sand	Ulen fine sandy sand	Hecla loamy sand	Hamar loamy fine sand	Hamar fine sandy loam
Planting date	5/18	5/19	5/19	5/20	5/24	5/23,24
Harvest date	8/8	8/8	8/6	9/29,30	10/6,7	10/6
Row spacing (inches)	40	38	38	40	38	36
Plant population	16,000	16,000	16,000	18,000	18,000	18,000
Soil chemical characteristics¹/						
Phosphorus test²/	Medium	Low	Medium	Medium	Low to medium	Very low
pH³/	7.5	7.1	7.6	6.1	7.5	7.1
Liminess⁴/	1	0	2	0	1	0

¹/ Soil sampled to depth of 6 inches.
²/ Standards of NDSU Soil Testing Laboratory
³/ On 1:1 soil: water suspension.
⁴/ Degree of effervescence with 10% HCl solution; 0 refers to none.

Table 2. Rate of nitrogen, phosphorus and potassium broadcast prior to final spring tillage.[1]

Cooperator	Year	Nitrogen (N)	Phosphorus (P)[3]	Potassium (K)[4]
		Nutrient rate, pounds per acre		
Jordheim	1965	70	25	25
Ista[2]	1965	70	25	25
E. Kummer	1965	70	25	25
R. Kummer	1966	160	70	66
Ista[2]	1966	70	31	29
Haverland	1966	80	35	33

1/ Fertilizers applied broadcast at the E. Kummer site were incorporated with a field cultivator; at all other sites the materials were plowed down.
2/ The sites adjoined.
3/ To express as P_2O_5, multiply by 2.3.
4/ To express as K_2O, multiply by 1.2.

P per acre), from concentrated superphosphate, banded about two inches to the side and two inches below the seed were established as main plots; and five rates of zinc (0, 5, 10, 30 and 60 pounds Zn per acre), from zinc sulfate monohydrate[b], banded at the same level as the phosphorus were established as subplots. In 1966, two rates of zinc (0 and 2 pounds Zn per acre) from di-sodium zinc ethylenediamine tetraacetate[c] broadcast prior to spring plowing were established as the main plots; and all combinations of three rates each of zinc (0, 1 and 4 pounds Zn per acre), from di-sodium zinc ethylenediamine tetraacetate, and phosphorus (0, 4.4 and 8.8 pounds P per acre, from concentrated super-phosphate, banded about two inches to the side and two inches below the seed were established as subplots. In both years nitrogen at 10 pounds N per acre from ammonium nitrate and potassium at about 17 pounds K from potassium chloride were banded on all subplots.

Each subplot in all trials was four rows wide and 50 feet long. Corn variety was P.A.G. 45, of 99-day relative maturity. Atrazine was broadcast after planting at recommended rates to control weeds.

Ears were harvested from 35 plants in each of the two center rows of each subplot. Moisture content was determined on eight ears selected at random from each subplot. These eight ears were dried and shelled. Grain yield was calculated as shelled corn at 15.5% moisture.

RESULTS

Deficiency symptoms were observed only on corn grown at the 1965 and 1966 Ista sites on the second and/or third leaves on plots not receiving zinc fertilizer. These symptoms did not disappear from leaves on which they were initially observed, but new leaves that developed as the season advanced did not display the symptoms. Early vegetative responses to zinc fertilizer were obtained only in the 1965 Ista trial.

Data which show the effect of zinc fertilizer on corn grain yields at the 1965 sites are presented in Table 3.

Table 3. Yield of shelled corn grain, 15.5% moisture, as affected by zinc fertilizer, 1965.

Rate of zinc (Zn)[1] (Pounds per acre)[2]	Jordheim[3]	Ista	E. Kummer
	Yield, bushels/acre		
0	82.9	105.6	93.9
5	77.9	104.2	92.9
10	76.2	107.3	93.1
30	81.3	109.0	92.7
60	81.8	113.4	91.1
LSD (10%)	N.S.[5]	5.6[4]	N.S.

1/ Source of zinc (Zn) was zinc sulfate monohydrate (36% Zn).
2/ Applied about 2 inches to the side and 2 inches below seed at planting.
3/ Hail damaged the leaves in August.
4/ The yield difference between the check (0 rate) and any other rate must be 5.6 bushels or greater to be significant at the 10% confidence level.
5/ The odds are less than 90 out of 100 that yield differences are due to zinc fertilizer rather than chance.

Corn grain yields in 1965 were increased by zinc fertilizer only at the Ista site and only by the 60-pound rate. This is the only site in 1965 at which yields exceeded 100 bushels per acre.

Zinc fertilizer increased corn grain yields at the Ista and Haverland sites in 1966. At the Ista site the broadcast zinc x banded zinc interaction was significant. This means that the effect on yield from banded zinc fertilizer was not the same at all levels of broadcast zinc. Data showing the effect of zinc on yield at the 1966 Ista site are shown in Table 4.

Table 4. Yield of shelled corn grain 15.5% moisture, as affected by broadcast and banded zinc, Ista 1966.

Rate of zinc (Zn) broadcast[1] lbs./acre	Rate of banded zinc (Zn)[1], lbs/acre: 0	1	4
	Yield, bushels/acre		
0	123.4 a[2]	136.3 d	134.7 cd
2	131.2 bcd	126.0 ab	127.9 abc

1/ Source was di-sodium zinc ethylenediamine tetraacetate ($Na_2ZnEDTA$).
2/ Yield figures followed by the same letter do not differ from each other at the 5% confidence level.

Data in Table 4 show that one pound of banded zinc (Zn) from $Na_2ZnEDTA$ was as effective in increasing yield as two pounds broadcast. Application of larger amounts did not produce greater yields.

b Supplied by Eagle-Picher, Cincinnati, Ohio.
c Supplied by Geigy Agricultural Chemicals, Ardsley, New York.

At the Haverland site banded zinc fertilizer increased yields but yields were not influenced by zinc applied broadcast. The data are presented in Table 5.

Table 5. Yield of shelled corn grain, 15.5% moisture, as affected by banded zinc, Haverland 1966.

Rate of banded zinc (Zn)[1]/, lbs/acre		
0	1	4
Yield, bushels/acre		
127.2a[2]/	140.3b	142.5b

[1]/ See Table 4 for explanation.
[2]/ See Table 4 for explanation.

At the Haverland site, one pound of banded zinc (Zn) was as effective as four pounds banded in producing a yield increase.

Zinc fertilizer did not increase corn grain yield at the R. Kummer site (based on statistical analysis), but data are presented in Table 6 to show the magnitude of yields.

Table 6. Yield of shelled corn grain, 15.5% moisture, as influenced by banded zinc, R. Kummer 1966.

Rate of banded zinc (Zn)[1]/, lbs./acre		
0	1	4
Yield, bushels/acre		
132.3	136.5	136.1

/[1] See table 4 for explanation.

Yield of corn without zinc fertilizer exceeded 120 bushels at all sites in 1966. Unlike the Ista and Haverland sites, grain yields were not increased by zinc fertilizer at the R. Kummer site.

Phosphorus fertilizer banded at planting did not influence yield response to zinc fertilizer in any of the trials (phosphorus x zinc interaction was not significant).

DISCUSSION

Symptoms on the leaves indicative of zinc deficiency are not the same for all corn varieties. The symptoms observed on the variety used was a bleached band, light yellow to white in color, about one-fourth to three-eighths-inch wide, extending from near the leaf sheath two-thirds of the way to the tip between the midrib and edges. In some corn varieties, symptoms on the leaves appear as several narrower white bands between the midrib and leaf edges, giving a striped appearance. Severe and prolonged deficiency results in stunted plants with short internodes and necrotic (dead) tissue on the part of the leaves on which the bleaching or striping had initially occurred.

Zinc deficiency symptoms were observed early in the growing season at two of the six sites (the 1965 and 1966 Ista sites). These symptoms did not disappear from the leaves on which they were initially observed, but new leaves that developed as the season advanced did not display symptoms of deficiency. The disappearance of zinc deficiency with advance in growing season is attributed to increase in both soil temperature and root growth. When soil temperature increases, more zinc becomes available to the plant because of more extensive root development and hence greater "exploration" of the soil mass. Also, an increase in temperature increases the availability of zinc within a given soil mass in a manner not known at present (1).

Yields in 1966 trials were higher than in 1965, even though soil conditions and fertilizer treatments were comparable. The somewhat lower yields obtained in 1965 may, in part, account for the lesser yield response to zinc fertilizer in that the demands for zinc were not as great. In the three trials in which yields were increased by zinc fertilizer, the yield without zinc fertilizer exceeded 100 bushels per acre. However, in one case corn yields in excess of 130 bushels (R. Kummer site) were produced, but responses to zinc fertilizer were not obtained.

Yield Response to Zinc

Yield responses to zinc at the 1966 Ista and Haverland sites were about the same, although no zinc deficiency symptoms were noted at any time during the growing season at the Haverland site. Thus, absence of deficiency symptoms cannot be used as a basis for judging probability of response from supplemental zinc. Occurrence of zinc deficiency symptoms early in the growing season does not always mean that yields will be increased by zinc fertilizer.

Two pounds of zinc (Zn) broadcast increased grain yield in some cases but the increase was no greater than from one pound banded. While a comparison of placement methods was not on an equal poundage basis, the band placement may be expected to be a more efficient method than broadcast because of the relative immobility of zinc in soil. This would be especially the case when low rates are applied and where deficiency occurs early in the growing season. Zinc applied broadcast is diluted with more soil than that applied in the band. Further, at equal application rates more zinc in placed close to the seed when banded than if applied broadcast. Thus, if a plant is to have access to the same quantity of fertilizer zinc applied