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ZINC FERTILIZATION OF CORN IN KENTUCKY

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Of the agronomic crops, corn is especially sensitive to zinc deficiency. The major symptom of zinc deficiency in corn is broad white stripes in the leaves at or near the growing point in the early growth stages of the plant. It has been referred to as "white bud" disease because of the characteristic whitish area on one or both sides of the midrib near the base of new leaves. It can be seen as a new leaf unfolds from the whorl. Growth is stunted resulting in shorter than normal internodes. The pith of the stalk may become darkened at the base of the stalk (below ground level) and at the first leaf node. Sometimes the lower leaves become purple.

FACTORS ASSOCIATED WITH ZINC DEFICIENCY

Zinc deficiency is more likely to occur during a cool, wet spring, and the symptoms often disappear after the soil becomes drier and warmer. Because zinc is immobile in soil, climatic factors which restrict early root growth may result in deficiency symptoms which disappear as root growth accelerates.

As a general rule, coarse textured soils are more frequently deficient in zinc than medium and fine textured soils. Calcareous soils (soils with unreacted calcium carbonate), regardless of their texture, are more likely to be zinc deficient than non-calcareous soils with pH values of 6.5 or less. However, even acid soils may be deficient in zinc.

Apparently there is an antagonistic effect of available phosphorus on zinc deficiency. The problem is likely to occur when a soil is naturally high in phosphorus or excess phosphorus is applied to a soil that is low in available zinc. It is referred to as "phosphorus-induced zinc deficiency." Phosphorus applications to a soil with an adequate supply of available Zn does not produce zinc deficiency.

Much of the available zinc of some soils is associated with the organic matter of the topsoil, with the subsoil horizons usually being lower in available zinc. When the topsoil is removed by erosion, terracing or land leveling, zinc deficiency may occur. In a field of zinc deficient corn, one can observe more intense deficiency in eroded portions of the field.

In Kentucky, zinc deficiency in corn has been observed in nearly every section of the state. However, it is most often observed in the Inner Bluegrass region, with somewhat lesser frequency in regions south of the Inner Bluegrass. Many soils of the Inner Bluegrass region are naturally high in phosphorus and low in available zinc. Additions of phosphorus fertilizer or lime intensifies the deficiency or near deficiency of zinc in these soils.

RESEARCH RESULTS IN KENTUCKY

Yield Response in Field Trials

Since 1967, field trials have been conducted on 73 sites in Kentucky, mainly in farmer's corn fields where zinc deficiency was identified or suspected. Yield of corn was measured on 54 of the 73 sites of field trials. These studies included 31 trials with zinc fertilizer broadcast, 28 trials with zinc fertilizer applied in corn rows, and 31 trials with foliar sprays of zinc.

Yield responses were grouped into four ranges, as shown in Table 1. Of the broadcast applications, 61 percent produced 10 or less bu/acre increase in yields, with 55 percent less than 5 bu/acre. Row applications appeared to be somewhat more successful, but 50 percent of these trials gave increases of not more than 10 bu/acre. Foliar application increased yields 10 bu/acre or less in 62 percent of the trials.

Table 1. Percentages of field trials resulting in various levels of yield responses in corn.

	Percent of Trials in Each Range			
Application Method	Less than 5 bu/A	5 to 10 bu/A	11 to 15 bu/A	More than 15 bu/A
Broadcast	55	6	19	20
Row	29	21	29	21
Foliar	26	36	6	32

Soil Test Results for Field Trial Sites

Soil test values for pH, phosphorus and zinc on the 73 sites of zinc field trials were grouped as shown in Table 2. About 88% of the samples from these sites had pH 6.0 or above. About 69% had pH 6.5 or above. Phosphorus tested high (61-300) or extremely high (300+) in 81% of the samples. Zinc tested less than 4.0 in 48% of the samples and was less than 8.0 in 89% of them.

Table 2. Grouping of field trial sites according to soil test values for pH, P and Zn.

Soil Test	Percent of Sites in Each Group			
pH	Less than 6.0	6.0-6.4	6.5-6.9	7.0 and above
	12	19	43	26
P	Less than 30	30-60	61-300	300 +
	0	19	48	33
Zn	Less than 4.0	4.0-7.9	8.0-11.9	12 and above
	48	41	10	1

The behavior of zinc in the soil-plant system is complicated, so it should be expected that interpreting zinc soil tests in terms of plant response to zinc fertilizer should also be complex. Our experiences confirm this. In about 50 field trials involving different soil types, cropping seasons, corn varieties, and management systems, we measured levels of zinc in corn plants, soil pH, and soil test levels of phosphorus and zinc. The results suggest that as soil pH increases from 6.0 to 7.0, the critical level for soil test zinc increases 100%, and, similarly, as soil test phosphorus increases from 40 lb/A to 450 lb/A, the critical level for soil test zinc increases about 100%.

Row versus Broadcast Application

Table 3 shows yields from a field trial on the Hollingsworth Farm, Scott County. These yields compare row applied with broadcast zinc and illustrate the residual effect of a high rate of broadcast application. The pH was 6.2, phosphate soil test was extremely high, and extractable zinc was 5 lb/A.

Table 3. Corn grain yields as influenced by row or broadcast applications to a zinc deficient Maury silt loam soil in Scott County.

Treatment Zn, lb/A	Site 1	2	3	4	Avg.
1971	----------------	bu/acre	----------------	----------------	----------------
0	88	56	119	71	83
1 (Row applied)	70	122	79	91	91
5 (Row applied)	121	121	114	96	115
30 (Broadcast)	91	98	118	101	102
1972					
0	92	130	112	124	114
30 (Broadcast 1971)	145	143	177	164	157

Data in Table 3 were not from randomized treatments within an area, but rather from a set of trials in adjoining sites within the field. Because of the extreme variation from site to site in the field, the average yields for treatments were not significantly different in 1971, but the trends were similar to those we have seen in many trials during the past several years. Plots receiving 30 lb Zn/A broadcast in 1971 produced plants showing noticeable symptoms of zinc stress, whereas in 1972 without receiving additional zinc, these plots produced healthy plants with no symptoms. We have observed this phenomenon in other trials and have interpreted it as being associated with more thorough mixing of zinc in the root zone by tillage operations.

Residual Effect of Broadcast Applications

In Table 4 are data from an experiment on the Maury silt loam soil at Lexington. Treatments were applied broadcast in 1969 and planted to corn with all crop residue being removed annually.

Initially, the soil test levels for zinc were fairly high on this soil and there was no significant response to zinc fertilization. Soil test levels for zinc declined, and, in 1973 and 1974, there were significant yield responses to fertilizer zinc. Soil test values and leaf tissue analyses both indicated that zinc applied in 1969 was decreased to levels of near deficiency by 1974. Corn grain and stover contain about 0.4 lb Zn/acre, so liming, phosphate fertilization and crop removal all probably had an effect in the system described here.

It is important to observe from Table 4 that 10 lbs Zn/A broadcast was not adequate to provide zinc for optimum yields and that the level of residual zinc appeared to be marginal 4 to 5 years after treatment.

Table 4. Corn response to single broadcast application of zinc sulfate made in 1969 to a Maury silt loam soil in Fayette County.

Treatment	1970		1973		1974	
Zn, lb/A	Yield bu/A	Soil Test Zn, lb/A	Yield bu/A	Soil Test Zn, lb/A	Yield bu/A	Soil Test Zn, lb/A
0	130	7.1	110	5.6	155	4.2
5	126	9.7	124	6.6	160	4.6
10	137	10.0	142	6.8	169	6.2

SUMMARY

These results illustrate that both diagnosis and correction of zinc deficiency are complicated. There is continuing need for response data for different soil types and for comparison of methods of application. The following suggestions are based on the most successful solutions to zinc problems in corn production that we have found thus far.

Broadcast application

If a problem field will be in corn production for several years, broadcast application is probably the most suitable. Our data indicate that 30 lbs/acre of elemental zinc is required for our silt loam soils. Residual zinc from 30 lbs Zn/acre should be adequate for 4 to 5 years. Silage production may cause more rapid depletion than grain production.

Row Application

Banding near the seed at planting usually increases efficiency of zinc fertilizer so that 6 lbs/acre of elemental zinc was usually sufficient. It is important to realize that zinc must be applied in the row annually, perhaps for 5 years of more, to assure adequate levels in the field. This application methods is most suited to deficient fields that are periodically planted to corn.

Foliar Spray

A foliar spray containing soluble zinc may result in profitable yield increases of corn on soils with slight zinc deficiency. Since the concentration of zinc in the foliar spray must be very low to prevent extensive foliar burning, one spray application will not supply enough zinc for optimum growth on soils where the deficiency is moderate or severe. On such soils, a foliar spray should stimulate growth temporarily and either a side dressing or broadcast topdressing of zinc fertilizer early in the growing season may be profitable, depending on seasonal conditions and the degree of zinc deficiency in the soil.

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