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Manganese Fertilization of Soybeans

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MANGANESE FERTILIZATION OF SOYBEANS

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Only a small quantity of manganese is essential for plant growth, however under certain soil conditions even this is not available to the plant. Depending on severity, manganese deficiency will retard plant growth and may drastically decrease yields. A deficiency of manganese will affect the photosynthesis system of the plant. The visual symptoms of a manganese deficiency on soybeans is interveinal chlorosis of the leaves. The veins remain green until the chlorosis nears the white stage then they also lose their color.

A shortage of manganese is linked to pH, soil type and organic matter. In the early 1960's, manganese deficiency on Kentucky soils was first observed in soybeans grown on fine textured soils having pH values of 6.0 and above in a few counties in the Green River and Pennyrile areas. Manganese deficiency is also affected by environmental factors (weather, etc.), and a deficiency will vary in severity from one year to the next. As the temperature increases into the growing season, soybeans sometimes grow out of mild deficiencies. The response of manganese deficient soybeans to fertilization is also variable. This may be one of the reasons that the response of manganese deficient soybeans to fertilization is less than expected in some cases. A number of trials have been carried out by the Agronomy staff at the University of Kentucky dating back to 1964. The results of the trials can be found below.

ROW FERTILIZERS WITHOUT MANGANESE

Fertilizer placed beside the row with no manganese has been found to be of some help on manganese deficient soils. The acidity produced by the fertilizer lowers the pH in the zone of placement and brings more manganese into solution. Complete fertilizers appear to be more effective than single nutrients. Results of comparison trials in manganese deficient soils can be seen in Table 1.

Table 1. Yields of soybeans treated with combinations of N, P_2O_5 and K_2O, Daviess County, 1964.

Treatment	*Yield (bu/acre)
Experiment 1	
Check (untreated)	26.8
Diammonium phosphate (71 lbs/acre)	30.7
0-20-20 (300 lbs/acre)	30.6
5-20-20 (300 lbs/acre)	31.6
Experiment 2	
Check (untreated)	27.4
Ammonium nitrate (15 lbs N/acre)	28.0
Superphosphate (60 lbs P_2O_5/acre)	27.9
Muriate of potash (60 lbs K_2O/acre)	27.6

*Average of 4 replications.

In some cases row fertilizer has completely eliminated manganese deficiency symptoms in fields with mild deficiency symptoms.

BROADCAST FERTILIZATION OF MANGANESE

Broadcast application of manganese fertilizers to correct a deficiency has been found to be inefficient and in most cases ineffective. Most Mn deficiency cases are not caused by the lack of Mn in the soil, but are due to soil conditions which cause the Mn to be unavailable for plant growth. Large amounts of broadcast manganese fertilizers are required to have any effect and most if not all of it is quickly rendered unavailable by the conditions present in the soil. In one case, 300 lbs. of actual Mn per acre did eliminate symptoms of Mn deficiency. The following tables show the lack of effectiveness of broadcast manganese fertilization.

Table 2. Effect of broadcast application of Mn fertilizer as manganese oxide on yield of soybeans, Daviess County, 1970.

Treatment	Mercer Farm	Hayden Farm	Ellis Estates
	*(Yield (bu/acre)		
Check (0 Mn)	27.2	25.1	41.2
30 lbs Mn/acre	29.3	23.3	43.2

*Average of 3 replications

Table 3. Yields of soybeans treated with combinations of Mn fertilizer topdress N and foliar-spray Mn, Daviess County, 1973.

Treatment (lbs/A)			Yield (bu/A) 1/
N	P_2O_5	K_2O	
0	200	200	26.6
0	200	200 + 100 N topdressed 2/	29.3
0	200	200 + Mn foliar spray 2/	28.3
0	200	200 + 50 Mn 3/	29.3
0	200	200 + 50 Mn + 100 N topdressed	28.8
0	200	200 + 50 Mn + Mn foliar spray	29.7

1) Av. 4 reps/tmt

2) Mn foliar spray was manganese sulfate

3) Mn fertilizer was Techmangan (27% Mn)

Table 4. Yields of soybeans with broadcast and row applications of Mn fertilizer, Daviess County, 1976.

Treatment	* Yield (bu/acre)
Check (unfertilized)	28.6
100 lbs Mn/ac. (broadcast and disked in)	29.8
25 lbs Mn/ac. (row placement 2" to side of seed)	35.1

*Average of 4 replications.
Mn source was Techmangan (27% Mn)

In the 1970 experiment, all differences are small and within the range of experimental error, thus, there was no response to manganese. Manganese deficiency was apparent in soybeans on the Mercer and Hayden Farms. The deficiency symptoms in the 1973 experiment were not noticeably affected by the broadcast manganese fertilizer. The 1976 experiment shows the increased effectiveness of row fertilization of manganese as compared to the broadcast application.

ROW APPLICATION OF MANGANESE

Row application of fertilizers with manganese have been much more effective than broadcast manganese fertilizers. When most of the commonly used fertilizers are added to the soil they are acid forming. When the fertilizer is added in a band beside the row, the acidity is concentrated in this band and will cause the pH to drop sharply. If manganese is added in the band, the more acid environment will help prevent it from being tied up and becoming unavailable. Although the results with manganese fertilizer beside the row are better, they are still quite

inconsistent. Research using row fertilizers containing manganese are seen below.

Table 5. Effect of row manganese fertilizer on soybean yields, 1973

Fertilizer	Graves	Todd	Hopkins*	Daviess	Ohio
lb/ac.			Yield (bu/acre)		
14-56-56	29.7	33.7	40.5	55.4	49.1
14-56-56 + 4 #Mn/ac.	38.6	43.9	44.9	59.3	45.2

*Only location to show manganese deficiency symptoms.

Table 6. Effect of row application of fertilizers containing manganese on soybean yields, 1974-76.

Treatment	Yield (bu/acre)
1974 McLean County	
7-28-28 (200 lbs/acre)	35.5
7-28-28 + Mn (2 lbs/acre)	34.2
7-28-28 + Mn (4 lbs/acre)	34.9
7-28-28 + Mn (8 lbs/acre)	38.4
1975 Daviess County	
Check (no fertilizer)	42.8
0-20-20 (200 lbs/acre)	44.1
0-20-20 + Mn (6 lbs/acre)	44.7
1976 Daviess County	
Check (no fertilizer)	41.6
0-30-30	42.9
0-24-24 + Mn (10 lbs/acre)	48.4

In many cases where Mn was added beside the row, the yields would be increased but the deficiency symptoms would still be present, although they would be less severe.

FOLIAR SPRAY OF MANGANESE

Our research shows this method of correcting Mn deficiency to be more consistently effective than soil application. When manganese is placed on the leaves for absorption into the plant, rates of manganese application per acre are much less than for soil application. This is fortunate from the standpoint that only small quantities can be effectively absorbed through the foliage at one time. Most Mn deficiencies in Kentucky can be corrected by adding 1 to 1 1/2 pounds per acre of actual manganese when the soybeans are 10 inches high or higher.

Even at these low rates, some burning of the foliage should be expected, but the plants quickly recover. Foliar fertilization with manganese doesn't always increase the yield, but it is the most consistent method we have. Especially when deficiences are severe, soybeans will still show some manganese deficiency after they have been sprayed with a manganese solution, but yields are usually increased, nevertheless.

Much of the research work has been carried out using manganese sulfate with the trade name of Techmangam, a by-product of the Kodak Manufacturing Process. Four to five pounds of Techmangam (27% Mn) was mixed with 20 to 25 gallons of water on an acre basis. The first work in 1964 indicated that 5 pounds of techmangam in 25 pounds of water per acre would increase yields about 2.5 bushels per acre. Treatments consisted of early spray only, later spray only, and spraying at both times. Time of spraying did not effect yields and some foliar burn was encountered on all treatments.

Table 7 shows a comparison of 3 different sources of manganese. All appeared to be about equally effective.

Table 7. Effect of foliar spray with manganese on yields of Mn deficient soybeans, Daviess County, 1972.

Treatment	Daviess County		Hopkins County
	Krampe Farm	Meadows Farm	Quinn Farm
Unsprayed	40.7	17.7	24.8
Techmangam (5 lb. in 25 gal H_2O)	45.4	27.2	35.3
Sequestrene (1 qt. per acre)	46.4	--	--
Lawel (3.5% Mn in 25 gal H_2O)	46.5	--	--

Table 8 shows the variability in response of manganese sprayed on soybeans over a three year period. Severe deficiency symptoms existed each year at the same location.

Table 8. Response of soybeans to foliar application of Techmangam, Daviess County, 1974-76.

Treatment	*Yield (bu/acre)
1974	
Unsprayed	19.4
Sprayed (Techmangam, 5 lbs/acre)	21.8
1975	
Unsprayed	27.2
Sprayed July 9	40.7
Sprayed July 21	39.6
Sprayed July 9 and 21	38.3
1976	
Unsprayed	28.6
Sprayed (Techmangam, 4 lbs/acre)	34.7

*Average of 4 replications.

SEWAGE SLUDGE ON MANGANESE DEFICIENT SOILS

The microorganisms in soil are at least partially responsible for the availability of manganese in the soil. In some soils with very low bacterial activity, manganese may be deficient because the bacteria haven't reduced it to an available form. In these soils, any type of easily decomposable organic material should increase manganese availability. Sewage sludge added to the field should accomplish this and at the same time add small amounts of manganese. An activated sewage sludge (milorganite) containing 0.25% Mn was broadcast on a Karnak silty clay soil on July 21, 1975. It eliminated deficiency symptoms in subsequent growth. Results are shown in Table 9.

Table 9. Effect of sewage sludge on yield of soybeans, Daviess County.

Sewage sludge (tons/acre)	*Yield (bu/acre)		
	1975	1976	2 yr. avg.
0	33.9	38.6	36.2
10	40.7	57.2	49.0

*Average of three replications.

SUMMARY

Results of experiments conducted to date with broadcast applications of inorganic manganese fertilizer applied at rates to supply up to 100 pounds of elemental manganese per acre have shown little evidence of being an effective method of correcting manganese deficiency in soybeans. Row fertilization showed some improvement in growth and yield in some experiments and had little effect in others. It appears to offer a better possibility in correcting manganese deficiency than broadcast fertilization.

Foliar spraying with a manganese fertilizer usually results in some burning of the foliage and is applied after the plants are under stress, which may reduce the yield potential. In some seasons the improved appearance of vegetative growth is not reflected in yield response, but a yield response for foliar spray has been evident in a number of the experiments.

The 10 ton application of sewage sludge (Milorganite, 0.25% Mn) showed a marked increase in soybean yields in 1975 and 1976. However, the cost of applying this commercial product at the rate of 10 ton per acre is prohibitive. If sewage sludge of comparable quality to Milorganite is available in the vicinity it should be tried on fields where manganese deficiency is a problem in soybean production.

Research studies with manganese deficiency in soybeans are being continued.