Manganese Deficiency and Fertilization of Soybeans

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Manganese deficiency of soybeans can occur on Coastal Plain soils when extractable manganese (Mn) is low and/or soil pH is high. Manganese supply is naturally low in poorly drained soils and sandy soils. Manganese availability is greatly decreased with increased pH. Generally, Mn deficiency of soybeans can be expected when soil pH exceeds 6.2 on somewhat poorly and poorly drained soils and when soil pH exceeds 6.5 on better drained soils. Symptoms of Mn deficiency are interveinal chlorosis of emerging leaves of soybean. Tissue analysis can also be used to evaluate the Mn status of the plant. The sufficiency range is 15-200 parts per million (ppm) Mn in the uppermost mature trifoliate leaf (petiole discarded).

A typical incidence of Mn deficiency. Chlorotic tissue was 7 ppm Mn. Soil pH was 7.0 and extractable Mn was 5.0 on the Goldsboro sandy loam producing this soybean crop.

Soil pH Controls Manganese Availability

Soil pH is the most important factor affecting Mn availability. The level of extractable Mn considered sufficient is highly dependent on soil pH. At a pH of 5.8, only 6.0 to 6.9 lb Mn/acre is needed to support optimum soybean growth. However at a pH of 6.5, 12.0 to 12.9 lb extractable Mn/acre is required. The levels of extractable Mn considered sufficient for soil pH levels of 5.5 to 7.0 listed in Table 1.

When soil conditions conducive to Mn deficiency exist, and/or the previous crop has shown Mn deficiency symptoms, Mn can be supplied to prevent or correct Mn deficiency of the soybean crop. Soil and foliar applications can both be effective methods of Mn fertilization.

Table 1. Range in extractable Mn level needed for sufficiency at various soil pH.

Soil pH	Extractable Mn needed for sufficiency, lb/acre	Soil pH	Extractable Mn needed for sufficiency, lb/acre
5.5	3.4-3.9	6.3	10.4-10.9
5.6	4.0-4.9	6.4	11.0-11.9
5.7	5.0-5.9	6.5	12.0-12.9
5.8	6.0-6.9	6.6	13.0-13.9
5.9	7.0-7.9	6.7	14.0-14.9
6.0	8.0-8.9	6.8	15.0-15.9
6.1	9.0-9.9	6.9	16.0-16.9
6.2	10.0-10.3	7.0	>17.0

Soil Applied Manganese

The availability of Mn fertilizers is reduced when incorporated into high pH soil. Therefore, the less soil the fertilizer is in contact with, the better. When broadcast 10 to 15 lb Mn/acre is needed to produce optimum crop growth, however, only 3 to 4 lb Mn/acre is needed when the Mn fertilizer is banded near the crop row.

High solubility Mn sources are more effective fertilizers than low solubility Mn sources. Manganese sources and their solubility are listed in Table 2. Manganese sulfates ($MnSO_4$) are highly soluble ranging from 71-100% water soluble. Manganese-oxysulfates range in solubility from 5 to 58% water soluble. Manganese oxide (MnO) is totally insoluble. Low solubility Mn-oxysulfates and Mn oxide can be effective Mn sources if finely ground (particle sizes less than 0.1-0.15 mm).

Most testing of chelated Mn fertilizers has been done based on economically comparable application rates rather than on a pound for pound basis, because chelated Mn sources are more expensive than inorganic Mn sources. Therefore, chelated Mn sources have typically been tested at rates of 1 lb Mn/acre or less. At these low rates, chelated Mn sources are ineffective at supplying Mn to the soybean crop when banded or broadcast to the soil. One chelate, Mn lignosulfonate, was tested at 13 lb Mn/acre and was shown to be a good source of Mn, but no better than $MnSO_4$ at the same application rate. There is little evidence that chelated Mn sources can be used at low rates and be as effective as recommended rates of $MnSO_4$.

Residual effects of Mn fertilization may occur. A broadcast application of 10 lb Mn/acre in a soil at pH of 6.5 produced optimum soybean yields in the first and second season after application. However, an initial application of 30 lb Mn/acre was needed to produce optimum yields in the third season after application. When incorporated into higher pH soils the residual effects of Mn fertilizers will likely be less than found in this instance.

Manganese can be mixed in the granular fertilizer and applied prior to planting. The less time the Mn is in the soil prior to when the crop needs it, the more effective the application will be in alleviating the deficiency. Applications should be made as close to planting time as possible and for one growing season at a time.

Foliar Manganese

Several inorganic ($MnSO_4$, $MnCl_2$, and $Mn(NO_3)_2$) and chelated (MnEDTA, MnDTPA, and Mn-lignosulfonate) sources of Mn are available for foliar application. All are equally effective at correcting Mn deficiency. The optimum rate of foliar-applied Mn is 0.1 to 0.2 lb Mn/acre, although 1 to 2 lb Mn/acre is a popular recommendation. The lowest effective rate is preferred because of lower cost, less likely leaf burn and ease in dissolving the fertilizer. Sources should be chosen based on these same factors.

Maximum yields are obtained when Mn applications begin at the first sign of visual deficiency symptoms. When the first spray is delayed 2 weeks, only 90% of maximum yield is achieved. A delay of 6 weeks results in only 70% of maximum yield. Additional sprays should be made when visual symptoms reappear. Two to three sprays are typically needed to make maximum yields.

SUMMARY

The likelihood of Mn deficiency in soybeans can be predicted from soil pH and extractable Mn level. When Mn deficiency is likely to occur, it can be prevented by soil application of Mn or corrected when symptoms occur by foliar applications of Mn. Rates of Mn application are highly dependent on the application method -- 10-15 lb Mn/acre broadcast to the soil, 3-5 lb Mn/acre banded near the crop row, or 0.1 to 0.2 lb Mn/acre applied to the foliage. Soil applications should be as close to planting time as possible. Foliar applications should be made as symptoms appear and again if symptoms reappear. The relative costs of soil applied versus foliar applications should be weighed. Since delayed spraying reduces foliar application effectiveness the likely timeliness of foliar application should also be considered. Water-soluble Mn fertilizers are good sources of Mn when applied to the soil or the foliage, but limited solubility Mn sources should only be used for soil applications and when finely ground. Chelated Mn sources should be applied at the same rate as soluble inorganic Mn sources. The ease at which Mn sources can be put into solution may also be a consideration.

Table 2. Manganese concentration and water-solubility of manganese fertilizers.

Fertilizer	% Mn	% Water solubility
Inorganic Sources		
Manganese chloride	17	100
Manganese frits	variable	-----
Manganese nitrate	<30%	100
Manganese sulfate	20-27	71-100
Manganese oxide	26-65	0
Manganese oxysulfate	28	5-58
Chelated Sources		
MnEDTA	6-12	100
MnDTPA	6	100
Mn-lignosulfonate	5	100