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Soil Fertility Series #1

Manganese Deficiency and Fertilization of Cotton

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Revised February 2004

Summary

Manganese (Mn) deficiency in cotton is not widespread, however it may occur. Fields where Mn deficient cotton is possible are those where deficiency has occurred in previous soybean, wheat, or corn crops or those with low available soil Mn (as determined by pH and soil test Mn levels). Little or no symptoms of Mn deficiency will be seen in the cotton unless the deficiency is severe. Tissue testing of the cotton leaf can be used to determine whether Mn is deficient. Manganese levels less than 25 ppm in the most recent fully expanded leaf (petiole discarded) are deficient.

Fertilization strategies for overcoming Mn deficiency are dependent on soil pH and available methods of fertilizer application. In soils where pH is marginally high (no greater than 6.2 in poorly drained soils and no greater than 6.5 in well drained soils) Mn fertilizers can be applied broadcast, banded, or foliar and residual Mn will be available in future seasons. At higher pH levels soil applications lose effectiveness, particularly when broadcast, and residual value will be negligible. In high pH soils banded and foliar applications are preferred and any soil applications should be made as close to planting time as possible. Rates of Mn application are highly dependent on the application method – 10-15 lb Mn/a broadcast to the soil, 3-5 lb Mn/a banded near the crop row, or 1 to 2 lb Mn/a applied to the foliage. Planned applications of foliar Mn should be made before first bloom. Earlier foliar applications to limited leaf area and mixing Mn fertilizers with glyphosate should be avoided. Foliar applications should be made immediately if deficiency symptoms appear and again if symptoms reappear. Water-soluble Mn fertilizers are good sources of Mn when applied to the soil or the foliage, but limited solubility Mn sources (like oxides or oxysulfates) should only be used for soil applications and when finely ground to particle sizes less than 0.1-0.15 mm. Chelated Mn sources should be applied at the same rate as soluble inorganic Mn sources.

Background Information

Manganese (Mn) is an essential nutrient for all plants. Manganese deficiency in cotton usually does not result in deficiency symptoms in contrast to the prominent deficiency symptoms that occur in soybeans, wheat, and corn. However, severely Mn deficient cotton may show yellowish-gray or reddish-gray discoloration of the youngest leaves while the veins remain green. Excessive soil Mn can be toxic at low soil pH. This condition is commonly referred to as crinkle leaf.

Only a few studies have been published examining Mn deficiency of cotton. The most pertinent to South Carolina are the experiments of Anderson and Boswell conducted in Gerogia during the 1960's (1). Eighteen tests were conducted over a 3-year period on soils with pH levels around 6.0 and water extractable Mn in the plow layer ranging from 0.5 to 10 pounds Mn per acre (lb Mn/a). Treatments were 0, 2, and 4 lb Mn/a as Mn sulfate sidedressed when the cotton had several true leaves. Seed cotton increases to Mn fertilization at the lowest levels of water extractable soil Mn were around 500 lb/a. Earliness was increased too. Yield decreases of less than 200 lb seed cotton/a occurred when fertilizer Mn

was added to soils with more than 7 lb/a water extractable soil Mn. Unfortunately, there is no way to compare the water extractable Mn levels used in the Georgia studies to more common soil test methods like the Mehlich I or dilute acid extractable methods used by Clemson, Georgia, and several other public and private soil testing laboratories. Little research has been done since the 1960's.

Soil Test Recommendations

At the time of the Georgia study it was noted that only South Carolina recommended the use of Mn for cotton production. As a result of their research, Georgia instituted a blanket recommendation of 2.5 lb Mn/a when soil pH was greater than 5.6. However, this recommendation was totally dropped in 1999 "due to lack of research supporting the need for the recommendation" (2).

Clemson's Mn fertilization recommendation was much more limited than the one first adopted by Georgia. Our long-standing recommendation is to apply Mn fertilizer when soil pH is above 6.2 in certain soils that are susceptible to deficiency (soil series like Yemassee, Lynchburg, and Rains) and/or deficiency has been observed in the field in previous years and confirmed with tissue testing (less than 25 ppm Mn in the leaf tissue). Both South Carolina and Georgia currently use soil test Mn levels and soil pH to flag potential Mn deficiency problems (see Table 1 on the next page). When liming a low pH soil use the target pH, not the actual soil pH, to assess soil Mn levels. These guidelines can be used for soil test reports from any laboratory using the Mehlich I or dilute acid extractable soil testing method. There is no evidence that Mn should be routinely applied to cotton fields in South Carolina. When Mn is needed it can be applied at 10 to 15 lb Mn/a broadcast, 3 to 5 lb Mn/a banded by the row, or 1 to 2 lb Mn/a as a foliar spray.

Soil Applied Manganese

High solubility Mn sources are more effective fertilizers than low solubility Mn sources (see Table 2 for values). Manganese sulfate sources ($MnSO_4$) are highly soluble ranging from 71-100% water soluble. Manganese-oxysulfates range in solubility from 5 to 58% water soluble. Manganese oxide (MnO) has very low solubility. Low solubility Mn-oxysulfates and Mn oxide can be effective Mn sources only when finely ground (particle sizes less than 0.1-0.15 mm). Chelated Mn sources can be soil applied but there is little evidence that they are more effective than $MnSO_4$, so they must be applied at comparable rates to correct Mn deficiency.

Manganese can be mixed in the granular fertilizer or liquid fertilizer and applied at, or prior to, planting. Recommended rates of application are 10-15 lb Mn/a broadcast to the soil or 3-5 lb Mn/a banded near the crop row. 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 deficiency. Therefore, applications should be made as close to planting time as possible. When incorporated into higher pH soils, particularly>6.5, there will be little available Mn remaining the second season after application so fertilize for one growing season at a time. Banding the Mn with an acid forming fertilizer increases availability and is the best way to insure availability of soil applied Mn. Foliar Mn may be an even better application method in excessively high pH soils.

Table 1. Guidelines for assessing available soil manganese (Mn) based on soil pH and soil test Mn using the Mehlich I or dilute acid extractable soil test method	
Soil test Mn, lb/a	**Soil- or foliar-applied Mn will probably be needed if the soil pH or target pH is equal to or greater than the following:**
4.0 - 4.9	**5.6**
5.0 - 5.9	**5.7**
6.0 - 6.9	**5.8**
7.0 - 7.9	**5.9**
8.0 - 8.9	**6.0**
9.0 - 9.9	**6.1**
10.0 - 10.3	**6.2**
10.4 - 10.9	**6.3**
11.0 - 11.9	**6.4**
12.0 - 12.9	**6.5**
13.0 - 13.9	**6.6**
14.0 - 14.9	**6.7**
15.0 - 15.9	**6.8**
16.0 - 16.9	**6.9**
17.0	**7.0**

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-lignin sulfonate	**5**	**100**

Foliar Manganese

Several inorganic ($MnSO_4$, $MnCl_2$, and $Mn(NO_3)_2$) and chelated (MnEDTA, MnDTPA, and Mn-lignin sulfonate) sources of Mn are available for foliar application (Table 2). All are equally effective at correcting Mn deficiency. The most common foliar rate recommended is 1 to 2 lb Mn/acre, however, research with soybeans has shown the optimum rate to be much lower – 0.1 to 0.2 lb Mn/acre. The lowest effective rate is preferred because of lower cost, less likely leaf burn, and ease in dissolving the fertilizer. Multiple applications may be needed when deficiency is severe.

Precautions for mixing manganese fertilizers with glyphosate

Foliar Mn fertilization of cotton prior to the 4-leaf stage is not recommended because of the limited leaf area available for Mn absorption. However if one does attempt to apply Mn early, be forewarned that extensive research in Michigan (3) and Virginia (4) has shown that Mn fertilizers tank-mixed with glyphosate reduce the effectiveness of glyphosate. The amount of reduction in weed control is dependent on the weed, Mn fertilizer, glyphosate formulation, and adjuvant. Weed control decreases may be as great as 50%. Reductions in control of common lambsquarter, large crabgrass, morningglory spp., smooth pigweed and velvetleaf were documented in these studies.

In the Michigan studies Mn sulfate, MnEAA (Mn-ethylaminoacetate), and Mn lignin sulfonate reduced glyphosate efficacy, but Mn-EDTA did not. Adding the adjuvants diammonium sulfate (AMS), EDTA, and citric acid lessened the reductions in weed control to various levels dependent on the Mn source. In the Virginia studies Mn-glucoheptonate reduced glyphosate efficacy more than Mn lignin sulfonate. A Fact Sheet from Monsanto Company states: “User assumes responsibility for weed control and plant health risks associated with tank mixtures of Roundup WeatherMAX and manganese fertilizers” (5).

References

(1) Anderson, O.E., and F.C. Boswell. 1968. Boron and manganese effects on cotton yield, lint quality, and earliness of harvest. Agronomy Journal 60:488-493.

(2) Harris, Glenn. 1999. Manganese Nutrition for Cotton. Cotton Newsletter, April 21, 1999. www.griffin.peachnet.edu/caes/cotton/cn141999.htm

(3) Bernards, M.K. Thelen, and D. Penner. 2002. The manganese fertilizer antagonism of glyphosate story for 2002. www.css.msu.edu/varietytrials/corn/Cropping%20Systems/mngly.pdf

(4) Bailey, W.H., D.H. Poston, H.P. Wilson, and T.E. Hines. 2002. Glyphosate interactions with manganese. Weed Technology 16:792-799.

(5) Monsanto Company. 2003. Recommendations for the use of Manganese with Roundup WeatherMAX® Herbicide in-crop on Roundup® Ready Soybeans. www.nachurs-alpine.com/images/Monsanto%20Manganese%20Recommendations%20061903.pdf