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Does Glyphosate Gene Affect Manganese Uptake in Soybeans?

Kansas study suggests superior yield response when manganese is added to glyphosate-resistant soybeans.

There is evidence to suggest that glyphosate-resistant soybean yields may still lag behind those of conventional soybeans. Many farmers have noticed that soybean yields even under optimal conditions are not as high as expected. In Kansas, average yield seldom exceeds 60 to 65 bu/A even when soybeans are grown with adequate rainfall and/or supplemental irrigation water. The addition of the gene that imparts herbicide resistance may have altered other physiological processes. Some scientists suggest that soybean root exudates have been changed and plants no longer solubilize enough soil Mn. Application of glyphosate also may retard Mn metabolism in the plant. Addition of supplemental Mn at the proper time may correct deficiency symptoms and result in greater soybean yields.

In higher plants photosynthesis, in general, and photosynthetic O_2 evolutions in Photosystem II (Hill Reaction), in particular, are processes that respond most sensitively to Mn deficiency. Manganese deficiency-induced changes in O_2 evolution are correlated with changes in the ultra-structure of thylakoid membranes (internal chlorophyll containing membranes of the chloroplast where light absorption and chemical reactions of photosynthesis take place). When Mn deficiency becomes severe, the chlorophyll content decreases and the ultra-

structure of the thylakoid is drastically changed.

Manganese acts as a cofactor, activating about 35 different enzymes. Manganese activates several enzymes leading to the biosynthesis of aromatic amino acids such as tyrosine and secondary products such as lignin and flavonoids. Flavonoids in root extracts of legumes stimulate *nod* (nodulation) gene expression. Lower concentrations of lignin and flavonoids in Mn deficient tissue are also responsible for a decrease in disease resistance of Mn-deficient plants. In nodulated legumes–such as soybeans that transport nitrogen (N) in the form of allantoin and allantoate to the shoot–the degradation of these ureides in the leaves and in the seed coat is catalyzed by an enzyme that has an absolute requirement of Mn. Ureides account for the majority of N transported in the xylem sap to the aerial portions of the soybean. Tissue Mn deficiency and drought stress can increase shoot ureide concentration. In research conducted in Arkansas, it was found that foliar Mn applications reduced soybean shoot ureide concentrations and prolonged N_2 fixation.

SUMMARY

In both years of the experiment, yield of a non-glyphosate resistant soybean variety was significantly greater than a glyphosate-resistant variety when no manganese (Mn) was applied. Application of Mn improved yield of the glyphosate-resistant variety but the yield of the conventional soybeans decreased with increasing Mn rate. Foliar application of chelated Mn also improved yield of the glyphosate-resistant soybeans.

Information is needed to determine if field-grown glyphosate-resistant soybeans respond to applied Mn in a manner different from conventional soybeans and, if so, what fertilization practices are best to correct the problem. Currently, there is little information on Mn fertilization of soybeans in Kansas.

The objective of this research was to determine if glyphosate-resistant soybeans respond differently to applied Mn from conventional soybeans and, if so, to develop different strategies that will improve yields for soybean producers by preventing or correcting possible Mn deficiencies.

Results

Conventional. In both years of the study, yield of the conventional soybean variety was significantly greater than the glyphosate-resistant variety when no Mn was applied. Yield of the conventional varieties declined at the highest Mn rate.

Glyphosate-resistant. Yield of the glyphosate-resistant varieties (Asgrow 3302RR, Figure 1 and KS 4202RR, Figure 2) increased with increasing Mn rate. Growth differences to soil-applied Mn were evident early in the season in both years of the study. Tissue Mn concentration (uppermost expanded trifoliate at full bloom) in the herbicide-resistant varieties was approximately less than half of the conventional varieties when no Mn was applied. Foliar-applied liquid Mn chelate also was effective in increasing yield of glyphosate-resistant soybeans.

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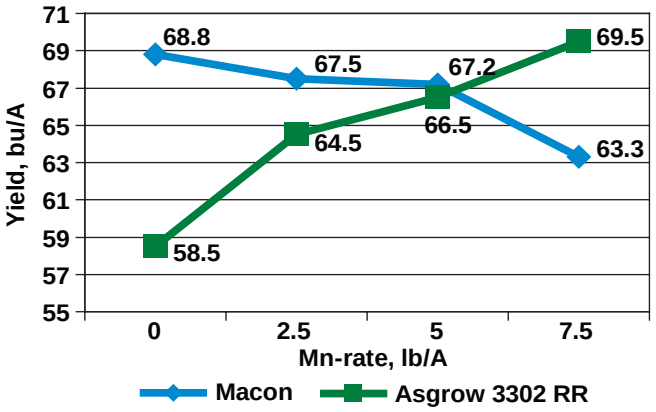

Figure 1. Soybean yield response to applied Mn; conventional = Macon; glyphosate-resistant = Asgrow 3302 RR; Kansas State U., Gordon, 2004-05.

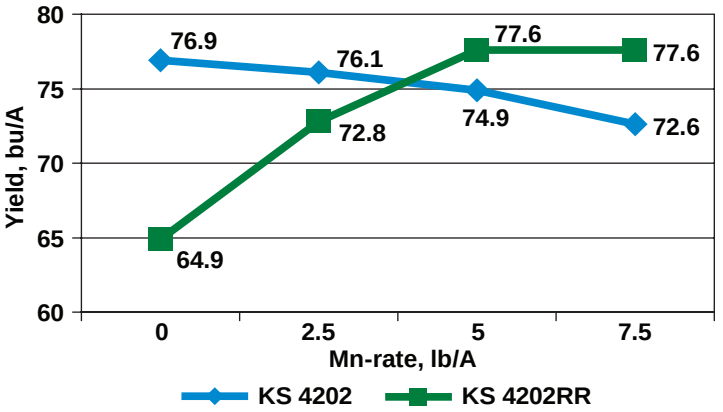

Figure 2. Soybean yield response to applied Mn; conventional = KS 4202; glyphosate-resistant = KS 4202 RR; Kansas State U., Gordon, 2004-05.