UNDERSTANDING THE MECHANISMS OF MANGANESE FERTILIZER ANTAGONISM OF GLYPHOSATE EFFICACY. Mark L. Bernards, Kurt D. Thelen, Donald Penner, Rajendra B. Muthukumaran, and John L. McCracken, Graduate Research Assistant, Assistant Professor, Professor, Postdoctoral Research Assistant, and Professor, Michigan State University, East Lansing, MI 48824.

Glyphosate-resistant soybeans are planted on approximately 80% of the soybean acreage in the United States. On soils where micronutrient deficiencies are common, dealers and producers favor tank-mixing glyphosate with a foliar micronutrient fertilizer. Both growers and researchers have reported antagonism of glyphosate efficacy by some Mn fertilizers (Bailey et al, 2002). The antagonism is dependant upon the fertilizer formulation. Fertilizers with strong chelating agents, such as EDTA, are less likely to antagonize glyphosate efficacy. In greenhouse trials, Mn fertilizer applied up to 3 days before glyphosate reduced control of velvetleaf. However, this phenomenon was specific to velvetleaf. Adding adjuvants such as AMS, EDTA, or citric acid to the tank-mix ameliorates the antagonism, but does not necessarily restore efficacy to the level achieved by a ‘glyphosate plus AMS’ treatment.

Based on the above results and previous work explaining the hard water antagonism of glyphosate (Thelen et al, 1995), our hypothesis was that Mn interfered with glyphosate absorption because it forms a complex with glyphosate in tank-mixtures.

Growth chamber bioassays were conducted to measure absorption and translocation of ^{14}C-labeled glyphosate in solution with four Mn fertilizers: Mn-ethylaminoacetate (Mn-EAA), Mn-EDTA, Mn-lignin sulfonate (Mn-LS), and $MnSO_4$. When velvetleaf plants reached the 4 leaf stage, the second oldest leaf was wrapped in foil and the plants were sprayed on a track sprayer at 187 L/ha. Glyphosate was applied at 0.28 kg a.e./ha; Mn-EAA, Mn-EDTA, and Mn-LS were tank-mixed with glyphosate at 9.4 L/ha, and $MnSO_4$ was tank-mixed at 7.85 kg/ha. The foil was removed and two 1 µL drops of treatment solution spiked with 1000 Bq/µL were placed on the adaxial surface of the leaf. The treated leaf was rinsed 4, 24, and 48 h after treatment and plants were harvested. Rinsate was analyzed by liquid scintillation. The harvested plants were divided into four parts, then dried, weighed, ground, combusted, and analyzed for ^{14}C-glyphosate by liquid scintillation.

Similar to what was observed in field and greenhouse trials, absorption and translocation of ^{14}C-glyphosate depended upon the fertilizer formulation included in the tank-mixture. Results paralleled what was shown in efficacy trials. Mn-EDTA did not interfere with absorption or translocation of ^{14}C-glyphosate. Both $MnSO_4$ and Mn-LS reduced glyphosate absorption and translocation. Surprisingly, glyphosate in tank-mix solutions with Mn-EAA was absorbed very rapidly. However, very little of the absorbed glyphosate was translocated to the growing point or roots from the treated leaf. Adding AMS increased the amount of glyphosate absorbed for each tank-mixture, and parallels the increased efficacy observed in field and greenhouse trials.

Manganese forms a complex with glyphosate in tank-mixtures. Electron spin resonance spectroscopy (ESR) is a tool used to analyze transition metal behavior in solution. Using ESR we learned that Mn^{2+} binds to glyphosate via the amine N. Each Mn^{2+} complexes with two glyphosate molecules. This is in contrast to calcium which binds to the phosphono- and carboxyl moieties (Thelen et al., 1995), and iron which binds at the phosphono-moiety (McBride and Kung, 1989).

Our results suggest that in fertilizers containting weakly chelated Mn^{2+}, Mn^{2+} forms a 2:1 complex with glyphosate and interferes with glyphosate absorption and/or translocation.

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