FOLIAR MANGANESE AND GLYPHOSATE FORMULATION YIELD EFFECTS ON GLYPHOSATE-RESISTANT SOYBEANS IN OHIO

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Abstract

In order to address the potential problems associated with glyphosate and manganese applications to glyphosate-resistant soybeans (*Glycine max* [L.] Merr.), an experiment with varying glyphosate and manganese micronutrient formulations and application timing was designed and carried out on two locations in Ohio to test effects on soybean yield. At the location in northwestern Ohio, the yields for all of the manganese-treated plots were significantly higher (P=0.1) than the untreated plots, regardless of the glyphosate formulation, manganese formulation, or timing. At the west-central location, manganese applications depressed yield, regardless of formulation and timing in comparison to the control plots, possibly due to the effects of different weather patterns between the locations.

Introduction

Soybean "flashing," or yellowing of leaves, is sometimes associated with glyphosate application in glyphosate-resistant soybeans, a suspected symptom of manganese deficiency, even in soils with levels of manganese considered sufficient. It is also suggested in the literature that manganese application to plants without deficiencies may be detrimental to crop performance. Though the tissue analyses usually show adequate manganese content, the chlorosis indicative of manganese deficiency reflects the possibility that antagonism between glyphosate and manganese in a tank-mix may exist, that sufficient uptake of manganese from the mix is not occurring. There have also been reports of reduced glyphosate efficacy on glyphosate-susceptible weeds in a tank-mix situation, as glyphosate chelates manganese, especially as inorganic salts (Huber, et al, 2004). However, differences were noted with different formulations of glyphosate. Also, delaying the manganese foliar application instead of tank-mixing it reduced the manganese deficiency symptoms.

Today, there are several organic-based manganese micronutrient solutions as well as several salt and adjuvant formulations of glyphosate commercially available to producers. The objective of this study is to determine how combinations of organic-form manganese and herbicide formulations and timing (either tank-mixed together or applied separately) affect glyphosate-resistant soybean yield.

Materials and Methods

This experiment was performed in 2007 in two field sites in Ohio, the OARDC Northwest Research Station near Hoytville, OH (41.22°N, 83.76°W; Hoytville clay loam [fine, illitic, mesic Mollic Epiaqualfs]), and Western Research Station (83.5°W and 39.8°N, Crosby silt loam [fine

mixed, mesic Aeric Ochraqualf]). Soil tests for both sites reported adequate pH and amounts of nutrients according to the Tri-State Fertility Recommendations (Vitosh et al, 1995). Neither site has a history of low soil manganese.

Glyphosate-resistant soybeans (Pioneer 92M91, Pioneer Hi-Bred, Johnston, IA) were planted at 150,000 seeds per acre. Each plot measured 10 x 40 feet. Treatments were assigned to plots in a randomized complete block design with four replications.

Foliar-applied product treatments included tank-mixing each glyphosate product with a manganese product at the R1 growth stage, and sequential foliar manganese applications 7 to 10 days after glyphosate treatments with a CO_2 backpack sprayer at 20 gallons per acre.

Two formulations of glyphosate differing in adjuvants and salt formulation were utilized: Roundup WeatherMax^R (potassium salt) and UltraMax^R (isopropylamine salt) (Monsanto Company, St. Louis, MO). Glyphosate treatments were applied at a rate of 1.1# acid equivalent per acre, and included ammonium sulfate at the recommended 17# per 100 gallons of spray solution.

The three manganese formulations used manganese mannitol (Claw-El Nitro Mn^R, Brandt Consolidated, Pleasant Plains, IL), manganese glucoheptonate (Claw-El Manganese^R), and manganese ethylenediaminetetraacetate, or EDTA, (Claw-El Manganese^R). These products varied in manganese content; the mannitol and glucoheptonate products contained 5% manganese, and the EDTA product contained 6% manganese. The labeled rate of these products was used in this study. Ammonium sulfate at the same rate contained in the glyphosate treatments was included in the treatments that contained no glyphosate. Soybean yield data was collected by combine harvesting 25 feet of row, adjusting for grain moisture. Contrasts between the treatments were analyzed with SAS PROC GLM.

Results and Discussion

Though no visual symptoms of manganese deficiency were observed at either site, slight and short-lived (2-3 days) glyphosate flash was observed. The Northwest site showed yield increases associated with any foliar manganese application versus no manganese applied. There were differences between the glyphosate formulations and the glyphosate and manganese source comparisons, most notably with the Nitro-Mn product and the two glyphosate formulations, where the UltraMax soybean yield exceeded that of the WeatherMax formulation (Table 1). Timing was significant for the Northwest site; the tank-mix of products out-yielded the sequential application of manganese after glyphosate (Table 2)

At the Western site, foliar manganese application depressed soybean yield compared to the untreated plots at P=0.1, regardless of manganese or glyphosate formulation (Table 3). There was a significant difference in yield for the main effect of timing from treatments with glyphosate-manganese applications compared to the control (no manganese) treatment, which was higher (Table 4).

Weather is suspected as playing a role in the differences in treatment effects on the soybeans, as rainfall was nearly 5" below normal at the Northwest site from planting through the R1 growth stage. Dry conditions favor less oxidized forms of manganese, not the plant-available Mn^{2+} in wetter weather (Havlin et al, 1999). The weather conditions at the Western site were not as water-stressed, and the addition of foliar manganese did not show crop yield improvement.

Table 1: Simple effects of glyphosate and manganese formulations at the Northwest Ohio location.

Manganese source	Glyphosate formulation	Soybean yield, Mg/ha
EDTA	WeatherMax	4.32
	UltraMax	4.32
Glucoheptonate	WeatherMax	4.23
	UltraMax	4.27
Nitro-Mn	WeatherMax	4.12
	UltraMax	4.43
Check	WeatherMax	3.91
	UltraMax	3.91
$LSD_{0.1}$		0.15

Table 2: Main effects of application timing at the Northwest site.

Application timing	Soybean yield, Mg/ha
Tank-mixed	4.38
Sequential	4.13
Check	3.91
$LSD_{0.1}$	0.09

Table 3: Simple effects of glyphosate and manganese formulations at the Western Ohio location.

Manganese source	Glyphosate formulation	Soybean yield, Mg/ha
EDTA	WeatherMax	3.55
	UltraMax	3.61
Glucoheptonate	WeatherMax	3.60
	UltraMax	3.56
Nitro-Mn	WeatherMax	3.67
	UltraMax	3.66
Check	WeatherMax	3.91
	UltraMax	3.71
$LSD_{0.1}$		0.17

Table 4: Main effects of application timing at the Western site.

Application timing	Soybean yield, Mg/ha
Tank-mixed	3.57
Sequential	3.67
Check	3.81
$LSD_{0.1}$	0.10

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