EFFECTIVENESS OF PREPLANT AND FOLIAR Mn ON SOYBEAN

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Manganese (Mn) has become a nutrient of interest in soybean production systems in the Midwest. This interest stems from reports from Purdue researchers of Mn uptake reductions caused by the glyphosate tolerant gene in soybean. Interest also has come from grain yield responses in Kansas.

Manganese is an essential nutrient for crop production. In cases where Mn is not available, a plant can not finish its life cycle without it. Mn is involved with photosynthesis and a cofactor in many plant reactions. Mn activates about 35 different enzymes in the plant and also is involved in nitrogen metabolism in the plant.

A Mn deficiency in the plant causes the veins to be green while the rest of the leaf turns yellow. This deficiency can also cause cupping of the leaf. These symptoms are similar to the symptoms of iron deficiency chlorosis.

Purdue Results

Huber (2007) reported reduced iron (Fe), Mn and zine (Zn) uptake through the roots when glyphosate was applied at 5% of the recommended rate (Table 1). He also reported that the translocation to the plant shoot of Fe, Mn, and Zn was reduced.

Table 1. Root uptake and translocation to shoot as affected by the application of glyphosate at 5% of the recommended rate.

Nutrient and glyphosate	Root uptake (%)		Translocation to shoot (%)	
	Control	+ glyphosate	Control	+ glyphosate
Iron	100	50	100	10
Manganese	100	19	100	9
Zinc	100	90	100	18

From these reported studies, Dr. Huber made these conclusions:

1. Do not use glyphosate as a carrier for micronutrients. The use of glyphosate as a carrier reduces nutrient uptake and nutrient utilization.
2. A grower should wait 6 to 8 days after glyphosate application for plant uptake to occur.
3. Herbicide efficacy, particularly with zinc products, was reduced.

Kansas Results

Gordon 2007 reported soybean grain yield increases for soybean varieties with the glyphosate tolerant genetics grown under high yield conditions in Kansas. Dr. Gordon's work was conducted on a silt loam soil with a neutral pH of 6.9. These soils were irrigated. He applied Mn preplant at broadcast rates of 0, 2.5, 5, and 7.5 pounds Mn per acre to a glyphosate tolerant

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variety and a non-tolerant variety. In two studies reported in the Fluid Journal, the application of Mn to non-glyphosate tolerant variety reduced soybean grain yields with increasing Mn application rates. The glyphosate tolerant variety grain yields were increased with the increasing rates of Mn (Figures 1 and 2).

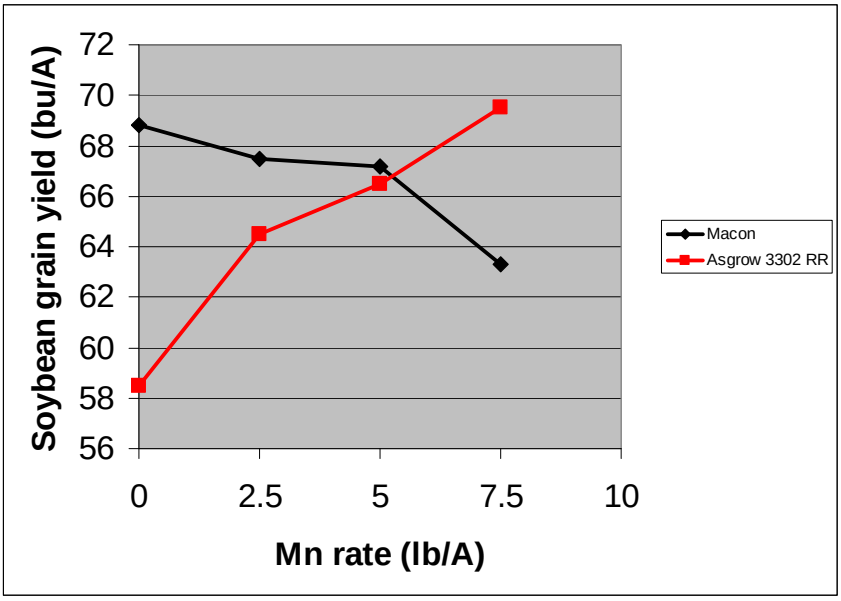

Figure 1. The response of soybean yield with (Asgrow 3302 RR) and without (Macon) the glyphosate tolerant genetics to soil applied Mn in irrigated high yielding conditions.

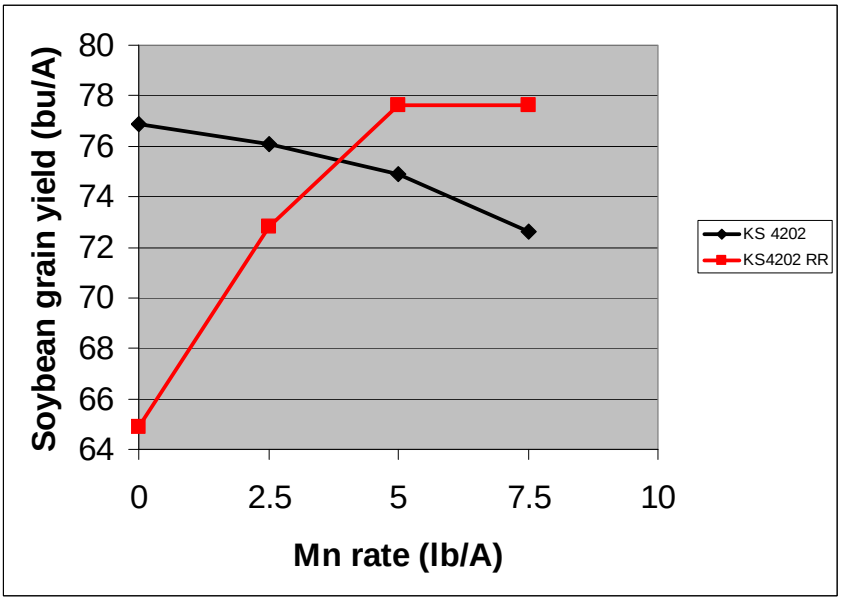

Figure 2. The response of soybean yield with (KS 4202 RR) and without (KS 4202) the glyphosate tolerant genetics to soil applied Mn in irrigated high yield conditions.

In both studies, the glyphosate tolerant varieties grain yields at 0 pounds Mn per acre were considerably less than the non-glyphosate tolerant varieties. It took 7.5 pounds of Mn per acre in the study reported in Figure 1 and 5 pounds Mn per acre in the study reported in Figure 2, for the glyphosate tolerant varieties to equal the grain yields of the non-glyphosate tolerant varieties. Dr. Gordon reported results at the 2007 American Society of American Annual Meetings that under non-irrigated lower yielding conditions, there was no response to Mn applications.

Illinois Results

Ebelhar et al. (2007) summarized extensive research conducted in Illinois involving the application of Mn with glyphosate tolerant varieties. This work was conducted in 2004 through 2006. There were several experiments conducted in each year. All experiments used three glyphosate tolerant varieties and Mn treatments of a check and 5 pounds Mn per acre surface applied immediately after planting. In 2004, a 0.5 pound Mn per acre foliar treatment applied 3 to 5 days prior glyphosate application. In 2005 and 2006, an experiment was established with a lime (L) treatment. The lime treatment was added to increase the soil pH and limit Mn availability to the plant. In the lime experiments, the 0. 5 pound Mn per acre foliar treatment was applied 10 days after the glyphosate application. In 2005 and 2006 studies without the lime treatment, there were two 0.5 pound Mn per acre foliar treatments. The foliar treatments were applied 3 to 5 days before or 10 days after glyphosate application.

The use of the lime treatment did not affect grain yields and are not reported. The use of Mn did not significantly affect soybean grain yields in this set of studies in Illinois (Table 2.)

Table 2. Soybean grain yields for as affected by Mn applications from 2004 to 2006 in Illinois (Ebelhar et al. 2007).

Treatment	2004	2005	2005L	2006	2006L
	---------- Soybean grain yields (bushels per acre) ----------				
Check	60.1	58.3	46.0	70.6	61.2
Soil 5 lb Mn/A	59.7	59.2	48.7	70.0	59.3
Foliar pre glyphosate	60.3	59.4	-	69.0	-
Foliar post glyphosate	-	58.2	46.8	70.8	61.0

Minnesota Results

In the summer of 2007, research was conducted in Minnesota at three sites, near Morris, MN, Lamberton, MN, and Rochester, MN. The Morris and Lamberton sites had calcareous subsoils, while the Rochester site was near neutral. At the Morris and Lamberton sites, the treatments included three variety/herbicide programs and Mn soil applied rates of 0, 2.5, 5, 7.5, and 10 pounds per acre before the final tillage operation. A 0.5 pound Mn per acre foliar treatment was applied at 6 to 8 days after the glyphosate herbicide was applied. The variety/herbicide program treatments were a conventional soybean variety (not glyphosate tolerant) with conventional herbicides, a glyphosate tolerant variety (similar to the conventional variety) with conventional herbicides (no glyphosate), and a glyphosate tolerant variety with glyphosate herbicide program. At the Rochester site, the treatments were different. The soil applied Mn treatments were applied at 0, 5, and 10 pounds per acre and a foliar 0.5 pound Mn per acre was applied 6 to 8 days after glyphosate application. Only one variety was used at Rochester, a glyphosate tolerant variety with a glyphosate herbicide program.

At the Morris and Lamberton sites, soybean yields were not significantly affected by any of the treatments (Table 3 and 4). There were significant periods of drought at both sites in 2007

that contributed to some variability in the yield results and possibly to the lack of grain yield response.

The results at the Rochester site were a little different. The application of 5 pounds Mn per acre significantly increased soybean grain yield greater than the check soybean grain yield (Table 5). The soybean grain yields from the rest of the treatments were not.

Table 3. Soybean grain yields as affected by variety/herbicide program and Mn application at Morris, Minnesota in 2007.

Mn application	Con/con †	Glyphosate/con	Glyphosate/gly	Mean
lb/acre	---------- Soybean grain yield (bushel per acre) ----------			
0	36	43	41	40
2.5	39	37	45	40
5	39	39	51	42
7.5	39	34	36	36
10	40	37	37	38
Mean	39	37	42	

† Con/con = conventional variety and conventional herbicide program.
Glyphosate/con = Glyphosate tolerant variety and conventional herbicide program.
Glyphosate/gly = Glyphosate tolerant variety and glyphosate herbicide program.

Table 4. Soybean grain yields as affected by variety/herbicide program and Mn application at Lamberton, Minnesota in 2007.

Mn application	Con/con †	Glyphosate/con	Glyphosate/gly	Mean
lb/acre				
0	50	48	49	49
2.5	50	47	47	48
5	50	50	50	50
7.5	51	46	51	50
10	50	47	47	48
Mean	50	48	49	

† Con/con = conventional variety and conventional herbicide program.
Glyphosate/con = Glyphosate tolerant variety and conventional herbicide program.
Glyphosate/gly = Glyphosate tolerant variety and glyphosate herbicide program.

Table 5. Soybean grain yields as affected by Mn application at Rochester, Minnesota in 2007.

Mn treatment (pounds Mn per acre)	Soybean grain yield (bushels per acre)
0	43
5	46
10	44
Foliar 0.5	43

Summary

The current take home message on Mn application to soybean is as follows:

1. Mn uptake and metabolism in soybean has been reported to be affected by glyphosate application.
2. Under high yielding conditions in Kansas, Mn application increased grain yields for glyphosate tolerant varieties up to the check yields for conventional varieties.
3. There was no grain yield response to Mn application in Illinois research.
4. There was no grain yield response to Mn application at Morris and Lamberton, Minnesota in 2007.
5. A small grain yield response to a 5 pound Mn per acre application occurred near Rochester, Minnesota in 2007.

Literature Cited

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