Effective Manganese Management for Corn and Soybean in Glyphosate-Dominant Cropping Systems

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Soybean leaf Mn levels

| Def. | Low | Suff. | High |
|------|-------|--------|---------|
| <15 | 15-20 | 21-100 | 101-250 |

Most recently mature trifoliate at early flower. Shulte and Kelling, 1999.



Soybean Mn Research (2007-2008)

- 3 locations: Wanatah (PPAC), La Crosse (J. Danford), Reynolds (M. Lehe)
- History of at least temporary Mn deficiency symptoms following glyphosate application to soybean
- Main Treatments for No-till Soybean:
 - 1. No Glyphosate
 - 2. Pre-plant Glyphosate only
 - 3. Pre plus one Post application of Glyphosate
 - 4. Pre plus two Post applications of Glyphosate at V3 and V6-V7
- Sub-treatments (Mn application)
 - 1. Control. Zero Banded MnSO₄
 - 2. Banded MnSO₄ at 3 pounds/acre
 - 3. Banded MnSO₄ at 6 pounds/acre
 - 4. Foliar Tank-mix Mn EDTA to #3 above







Soil pH and Mn Status at Test Sites

| Year | Location | Soil pH Mean | Soil pH Range | Soil Mn Mean (ppm) | Soil Mn Range (ppm) |
|------|----------|-----------------|------------------|--------------------------|---------------------------|
| 2007 | PPAC | 5.9 | 5.5~6.6 | 8 | 4~21 |
| | Rice | 5.9 | 5.2~6.6 | 3 | 2~6 |
| | White | 7.0 | 6.5~7.3 | 13 | 4~48 |
| 2008 | PPAC | 6.6 | 6.1~7.0 | 12 | 5~24 |
| | Rice | 6.7 | 5.9~7.2 | 6 | 4~10 |
| | White | 7.1 | 6.5~7.8 | 14 | 5~31 |





Leaf Symptoms and Sampling 4 Times/year









Glyphosate Influence on Mean Soybean Yield without Mn addition in 2007 and 2008 (mean of 3 locations/year)







Relationship of Leaf Mn to Soil pH in 2007



Starter versus Foliar Mn for Soybean with pre and post Glyphosate (mean of 3 locations)







Soybean Yield Response to Soil Zn versus Mn (White County, 2007)



Relationship of Soybean Yield to Leaf Zn (Rice, 2008)







Control versus Second Foliar Mn 2008







2008 Soybean Yield Response (bu/acre) to Single versus Double Foliar Mn Application after Glyphosate

| Glyphosate Treatment | Single Foliar Mn | Double Foliar Mn |
|-------------------------|------------------|------------------|
| Control | 2.6 | 3.1 |
| Pre Glyphosate | 1.7 | 3.5 |
| Pre + Post Glyphosate | 0 | 4.8 |
| Pre + 2 Post Glyphosate | 0 | 2.2 |

Note: All treatments had single post application of glyphosate to prior corn in 2007. Location is Wanatah, IN (PPAC)





Research Objectives (2009-2012)

- <u>Objective 1:</u> To help farmers better understand soil, environment, and soybean management factors reducing micronutrient availability.
- <u>Objective 2:</u> To assist farmers in determining optimum mode for micronutrient supplementation in RR soybeans for Mn and Zn individually and combined, or when both are mixed with other micronutrients.





Foliar micronutrient products applied to soybean in 2009 and 2010



Pinney (PPAC), Wanatah



White County



Soybean Yield Response (bu/acre) to Single Foliar Mn Application at Four Glyphosate Intensities (2008-2010)

| Glyphosate Treatment | No Foliar Mn | With Foliar Mn |
|-------------------------|--------------|----------------|
| Control | 43.5 | 46.2 |
| Pre Glyphosate | 46.7 | 48.7 |
| Pre + Post Glyphosate | 46.0 | 48.3 |
| Pre + 2 Post Glyphosate | 46.7 | 49.0 |

Note: All treatments followed Roundup-Ready corn with 0, 1 or 2 glyphosate applications. Location is Wanatah, IN (PPAC)





Soybean Yield Response to Foliar Nutrient Products and Rates (Wanatah, IN, 2009)

| Treatment | Mn Rate | Yield | Δ Yield |
|----------------------------|----------------|----------------|----------------|
| | (per acre) | (bu/acre) | (%) |
| Control (no Mn) | | 14.5e | 0 |
| Mn powder at V4 | 0.25 lb | 30.2 c | 108.3 |
| Mn powder at V4 | 0.50 lb | 30.5 c | 110.1 |
| Mn powder at V4 | 1.0 lb | 36.3 ab | 150.3 |
| Mn powder at V4 | 2.0 lb | 37.6 a | 159.3 |
| Mn EDTA at V4 | 32 oz | 27.5dc | 89.5 |
| Mn EDTA at V4 | 64 oz | 23.1d | 59.1 |
| Manni-Plex for Beans at V4 | 60 oz | 30.4c | 109.6 |
| Manni-Plex for Beans at V4 | 120 oz | 31.7bc | 118.6 |
| Mn powder at V4 and R1 | 0.50 lb | 29.2c | 101.6 |
| Mn powder at V4 and R1 | 1.0 lb | 36.2 ab | 149.9 |
| Mn powder at V4 and R1 | 2.0 lb | 36.7 ab | 153.3 |
| Mn powder at V4 and R1 | 4.0 lb | 38.8 a | 167.4 |





Soybean Response to Glyphosate and Foliar Nutrient Products (White County, 2009)

| Treatment | Foliar Nutrient | Yield | Δ Yield |
|-----------------------------------|---------------------|----------------|----------------|
| | Rate/ac | (bu/ac) | (%) |
| Main | | | |
| Glyphosate at V4 | 22 oz | 37.3 a | |
| Glyphosate at V4 and R1 | 22 oz | 34.6 b | |
| Sub-treatment | | | |
| Control (no micronutrient) | 0 | 31.5 c | 0 |
| Mn #1 (EDTA Mn) | 32 oz | 36.6ab | 16.1 |
| Zn #1 (Super Tel Zn) | 0.25 lb | 30.4 c | -3.5 |
| Mn1Zn #1 | 32oz Mn + 0.25lb Zn | 36.7 ab | 16.3 |
| MnZnNBo #1 (Manni-Plex) | 60 oz | 39.8 a | 26.5 |
| ProMn #1 (Tetra Pro Mn) | 38 oz | 36.3ab | 15.3 |
| MnZn #2 (applied twice) | 32oz Mn + 0.25lb Zn | 38.4 ab | 21.7 |
| MnZnNBo #2 (applied twice) | 60 oz | 37.8 ab | 19.9 |
| ProMn #2 (applied twice) | 38 oz | 35.7b | 13.4 |





Soybean Leaf Nutrient Response to Glyphosate and Foliar Nutrients (Wanatah, July 29, 2010)

| Treatments | Foliar Nutrient Rate/ac | Zn | Mn |
|---------------------------------|--------------------------|-------|-------|
| | | (ppm) | (ppm) |
| Main | | | |
| Glyphosate at June-25 | 22 oz | 53.4 | 45.6 |
| Glyphosate at June-25 + July-9 | 22 oz | 50.7 | 48.3 |
| Sub-treatment | | | |
| Control (no micronutrient) | 0 | 47.3 | 38.4 |
| Mn #1 (EDTA Mn) | 32 oz | 46.3 | 39.5 |
| Zn #1 low rate (super Tel Zn) | 0.25 lb Zn | 45.6 | 39.8 |
| Zn #2 high rate (super Tel Zn | 0.50 lb Zn | 45.3 | 37.8 |
| Mn+Zn #1 | 32oz Mn + 0.25lb Zn | 44.8 | 37.4 |
| MnZnNBo #1 (Manni-Plex) | 60 oz | 46.9 | 38.2 |
| Zn #2 high rate (applied twice) | 0.50 + 0.50 lb Zn | 60.3 | 69.0 |
| MnZn #2 (applied twice) | (32oz Mn + 0.25lb Zn) x2 | 86.4 | 76.2 |
| MnZnNBo #2 (applied twice) | 60 oz + 60 oz | 46.5 | 65.2 |



Soybean Seed Response to Glyphosate and Foliar Nutrients (Wanatah, 2010)

| Treatments | Foliar Nutrient Rate/ac | Mn | Yield |
|-----------------------------------|-------------------------|-------|--------|
| | | (ppm) | bu/ac) |
| Main | | | |
| Glyphosate at June-25 | 22 oz | 21.8 | 52.6 |
| Glyphosate at June-25 + July-9 | 22 oz | 20.3 | 53.7 |
| Sub-treatment | | | |
| Control (no micronutrient) | 0 | 20 | 52.7 |
| Mn #1 (EDTA Mn) | 32 oz | 21 | 55.1 |
| Zn #1 low rate (Super Tel Zn) | 0.25 lb | 22 | 54.1 |
| Zn #2 high rate (Super Tel Zn | 0.50 lb | 20 | 52.8 |
| Mn+Zn #1 | 32oz Mn + 0.25lb Zn | 21 | 53.6 |
| MnZnNBo #1 (Manni-Plex) | 60 oz | 21.5 | 52.6 |
| Zn #2 high rate (applied twice) | 0.50 + 0.50 | 21 | 53.2 |
| MnZn #2 (applied twice) | (32oz Mn + 0.25lb Zn)x2 | 21.5 | 51.5 |
| MnZnNBo #2 (applied twice) | 60 oz + 60 oz | 21.5 | 52.9 |





Foliar micronutrients applied to corn



crop, soil, and environmental sciences

Corn Yield Response to N at 3 Plant Densities: (Mean of 2 RW-res. hybrids, Wanatah, IN, 2010)



Tentative Mn and Zn Recommendations in Glyphosate-Resistant Soybean

- 1. Post-emergence glyphosate applications aren't inherently negative for soybean leaf or seed nutrient concentrations.
- 2. Glyphosate application intensity doesn't seem to affect soybean yield or relative response to foliar micronutrient applications.
 - **3.** Soil pH, rain (moisture), and soil micronutrient concentrations are bigger factors in trifoliate leaf and final seed nutrient concentrations.





Tentative Mn and Zn Recommendations in Glyphosate-Resistant Soybean (cont.)

- 4. Although soil Mn is important, starter-band Mn by itself is not effective. That could change with Mn formulation or with multi-nutrient starters (especially with acidforming fertilizers).
- **5.** Timing for foliar Mn applications may be important (7-14 days after each?? post glyphosate), but positive yield response is not guaranteed due to soil nutrient and moisture fluctuations as soybean growth continues.
- 6. Double foliar applications maintain optimum leaf Mn and Zn concentrations post flowering, but don't necessarily boost yield. Aim for lower cost Mn and Zn sources if higher rates are required.





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John Deere Cropping Systems Unit

Soybean Seed: Pioneer Hi-Bred, Int.





Thanks!

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Plant density and Nitrogen Rate Relationships with Grain Yield and NUE





