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PURDUE EXTENSION WEED SCIENCE

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Glyphosate – Manganese Interactions and Impacts on Crop Production: The Controversy

We have been getting many phone calls concerning the recent No-Till Farmer article 'Are We Shooting Ourselves in the Foot with the Silver Bullet?' (http://fhrfarms1.com/notillglyphosate.pdf). In this article based on an interview with Dr. Don Huber (retired plant pathologist from Purdue University), it is alleged that the non-judicious use of glyphosate has induced micronutrient deficiencies which have led to more plant disease. In our opinion the doomsday scenario painted by this article is greatly exaggerated. A more balanced assessment of the non-target effects of glyphosate is available in the article 'Glyphosate Manganese Interactions in Roundup Ready Soybeans' (http://www.weeds.iastate.edu/mgmt/2010/glymn.pdf) written by Dr. Bob Hartzler (weed scientist at Iowa State University). The extent of glyphosate and glyphosate-resistant crops on the manganese (Mn) nutrition of soybeans is not agreed upon, nor fully understood. We are concerned that the article in No-Till Farmer encourages growers to make drastic changes to their fertility, weed, and disease management programs out of fear, not understanding. We suggest the following approach to managing Mn deficiency in soybeans.

Manganese deficiency of soybean is not a new phenomenon, being identified as a problem in particular soils of northern Indiana nearly 75 years ago. Manganese deficiency of corn is less common and less severe than in soybean, but occurs in the same soils and geographic region. Alleviating Mn deficiency still remains difficult even though we have known about it for a long time.

Photo 1. Classic symptoms of manganese deficiency on soybean and corn grown on high pH, high organic matter soils at the Pinney Purdue Agriculture Center, Wanatah, Indiana.

Created 4/8/2010

Purdue Extension Knowledge to Go 1-888-EXT-INFO

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Manganese deficiency is not hard to spot. Symptoms of Mn deficiency are distinctive, interveinal yellowing of the leaf while the veins remain dark green (Photo 1). Analyzing the Mn concentration of the uppermost fully expanded trifoliate leaf of soybean or the earleaf of corn has traditionally been used to confirm Mn deficiency. In the past leaf Mn greater than 20 parts per million (ppm) was considered sufficient for both crops. Recently however, Mn deficiency in soybean has been documented at leaf Mn greater than 30-40 ppm. A recent assessment of the corn leaf Mn critical level is not available.

Soil conditions promoting Mn deficiency are high pH and low soil moisture. In many northern Indiana soils high pH is an inherent characteristic of the soil, not a result of over-liming, so it is not easily changed by the farmer. Higher organic matter is also associated with increased Mn deficiency. Thus, Mn deficiency often occurs in depressional areas in mineral soils and on muck soils. The soil test Mn level needed for sufficiency is pH and soil organic matter dependent (Table 1). When liming is needed on mineral soils prone to Mn deficiency, maintain soil pH below 6.3. On organic soils keep pH below 5.8. Rainfall can alter the severity of Mn deficiency within and between seasons - the wetter the soil the greater the Mn availability. Manganese deficiency symptoms will often disappear during periods of high rainfall and get more severe with drought. Manganese availability is higher in soybean-corn rotations than in continuous soybean.

Table 1. Approximate soil test manganese level needed for sufficiency in mineral and organic soils based on soil pH (adapted from AY-9-32, Tri-State Fertilizer Recommendations - http://www.ces.purdue.edu/extmedia/AY/AY-9-32.pdf).

	Mineral soils	Organic soil[1]
Soil pH	**Soil test level needed for sufficiency, ppm[2]**	
5.8	1	8
6.0	3	14
6.2	7	19
6.4	11	25
6.6	14	30
6.8	18	35
7.0	21	41

[1] Greater than 20% organic matter content.
[2] 0.1 N HCl extractable Mn

Soil-applied fertilizer Mn is relatively ineffective at correcting Mn deficiency because it becomes unavailable soon after application. To maximize the availability of soil applications, band the Mn fertilizer in 2x2 placement with an acid-forming phosphorous-containing fertilizer, for example Mn sulfate and 10-34-0 (ammonium polyphosphate). Recommended rates of application are 1-12 pounds of Mn per acre and vary dependent on soil-test Mn, soil pH, and organic matter. In situations where Mn deficiency is expected to be severe a banded application may produce a large enough plant to spray with a foliar Mn fertilizer later.

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Foliar-applied Mn is the most effective method for overcoming Mn deficiency in most situations. For maximum effectiveness apply Mn as soon as deficiency symptoms appear. Yield is decreased about 5% for each week delay in spraying after Mn deficiency symptoms first appear. Since Mn is not readily remobilized within the plant, deficiency symptoms often reappear requiring a 2nd or possibly 3rd application. A rate of 0.2-0.5 pounds of Mn per acre per application is sufficient for maximum yield in most cases. When sprayed alone (without glyphosate) most Mn fertilizers are equally effective, thus cost becomes the primary factor in choosing an economical Mn fertilizer.

All Mn fertilizers interact with glyphosate in a tank mix, some more than others, resulting in reduced herbicide efficacy and lower Mn availability. The reduction in herbicide efficacy is most likely noticed when attempting to control weeds that glyphosate has trouble with, such as velvetleaf (Photo 2). Manganese EDTA is the least antagonistic Mn fertilizer to glyphosate and it is preferred for tankmixing, especially when hard to control weeds are prevalent in the field to be treated. Alternatively, foliar Mn may be applied in a separate application 7-10 days after the glyphosate application. However, the delay in Mn application may result in yield loss, negating some of the benefit of separate Mn fertilizer and glyphosate applications.

Photo 2: Greenhouse grown velvetleaf illustrating the reduction in glyphosate effectiveness when tank mixed with manganese (Mn) fertilizers. Although Mn-EDTA was less antagonistic to glyphosate it still reduced weed control. All treatments labeled +Mn received glyphosate. The shorter the plant the greater the effect of the glyphosate.

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Summary

Manganese deficiency symptoms on soybean are obvious and typically occur in the same fields and same areas of a field year after year. If you are farming a field with a history of Mn deficiency, be prepared to address it when it occurs. If deficiency is severe, consider banding Mn with an acidifying phosphorous-containing fertilizer to produce enough leaf area to treat with a foliar Mn fertilizer. Apply foliar Mn as soon as deficiency symptoms appear and again if they reappear. If tankmixing Mn with glyphosate, choose a form that is minimally antagonistic to the glyphosate. Yield reductions can occur when Mn is applied to soybean not needing Mn, so 'insurance' applications of Mn are not recommended. Routine applications of Mn or other micronutrients to alleviate the alleged impacts of glyphosate on plant disease are also not warranted. Glyphosate applications should be managed to avoid weed resistance.