Corn Response to Manganese Rates

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Introduction

There is increased interest in micronutrient application for maximizing corn and soybean yield. Manganese is promoted by some agronomist to increase soybean yield. However, soybean yield increases resulting from foliar Mn application rarely occur in most Midwestern U.S. soils except where deficiency symptoms are evident or where soil test results show low plant-available Mn. Soils with these characteristics frequently have a combination of high organic matter and high pH. Recommended foliar application rates are usually 0.2-0.5 kg Mn ha^{-1}, with maximum recommended rates of 1 kg Mn ha^{-1}. Soil applications are generally not recommended because of the risk of Mn being oxidized and becoming unavailable for plant uptake.

Mn-deficiency is rarely reported in corn, and little research has been reported on the effects of additional Mn to corn. In the spring of 2010 a field in Nebraska received a soil application of 8.3 kg Mn ha^{-1} in the form of manganese sulfate. Corn planted following the application was severely stunted and chlorotic, and yield was significantly reduced compared to long-term field averages. In response to this observation, studies were conducted in 2012 in Nebraska and in 2012 and 2013 in Illinois to evaluate the effect of increasing Mn dose applied to the soil on corn growth and yield.

Table 1. Effect of increasing Mn concentration in the substrate on uptake rates of Mn and Mg by soybean roots.

Nutrient	Mn supply (µM)		
	1.8	90	275
Manganese	0.5	3.1	4.8*
Magnesium	121.8	81.1	20.2

* Data are expressed as micromole of nutrient taken up per gram of root dry weight, based on Heenan and Campbell (1981).

Materials and Methods

- Field trials were established near Macomb, Illinois and near Dannebrog, Nebraska in 2012. Each study was replicated four times. The Nebraska location was in ridge-till, and the Illinois location was in a no-till.
- In Nebraska, manganese sulfate (32% Mn) was applied prior to planting as dry granules rates of 0, 3.4, 5.6, 9, and 12.6 kg Mn ha^{-1} to the top of the ridge. Plots were 2.7 x 6 m^2. Corn hybrid P33D49 was planted in 0.91 m rows and 69,000 plants ha^{-1}. Corn was hand-harvested from three 4 m^2 areas within each plot, weighed and adjusted for moisture (15%). The soil was Thurman Loamy fine sand. The location was irrigated.
- In Illinois, manganese sulfate (32% Mn) was applied prior to planting using a backpack sprayer calibrated to deliver 160 L ha^{-1}. Mn rates were 0.37, 1.1, 3.4. 6.7, and 10 kg Mn ha^{-1}. Plots were 9.1 x 11.4 m. Corn hybrid N68B-3122 was planted in 0.75 m rows at 89,000 plants ha^{-1}. SPAD readings to measure chlorophyll were collected by measuring the newest fully extended leaf periodically throughout the growing season. The plots were machine harvested, weighed and adjusted for moisture (15%). The soil was a Rozetta silt loam.
- In 2013 the study was repeated in Illinois. On a complex of Keomah and Clarksdale silt loams. Corn was planted in the 2012 location and no additional Mn was added but SPAD readings were collected. The second location received Mn application in 2013 and was treated identically to the 2012 study.

Results

- In Illinois in 2012 and 2013, SPAD meter readings were not affected by Mn rate (Table 2).
- In Nebraska, plants growing in plots that received Mn application were chlorotic and stunted relative to untreated plots (Fig 1). In addition, they expressed symptoms of reddening of the stems and leaf margins and interveinal beading(Fig 2).
- In Illinois in 2012, yield was not affected by Mn treatment (Fig 3).
- In Nebraska, yield was reduced by all Mn rates (Fig 4). However, yield loss did not increase as Mn rate increased above 3.6 kg ha^{-1}.

Table 2. SPAD meter readings as affected by Mn application rate. 2012 and 2013 (year 2) represents readings after Mn was applied in 2012, and 2013 (year 1) represents readings taken after Mn was applied in 2013. There were no statistical differences (p=0.05).

Mn rate kg Mn ha^{-1}	Days after application				
	2012	2013 (year 2)		2013 (year 1)	
	51	407	428	65	86
0	39.7	55.3	54.5	54.7	43.1
0.4	40.6	55.2	52.0	52.9	42.5
1.1	42.0	55.0	53.4	52.9	43.8
3.4	39.5	55.0	54.3	50.5	41.4
6.7	41.4	54.7	55.4	50.4	41.3
10	39.5	54.3	52.7	52.5	43.6

Figure 1. Comparison of Mn-treated (left) and untreated (right) plant size in NE.

Figure 2. Reddening of leaf characteristic of Mn treated plants.

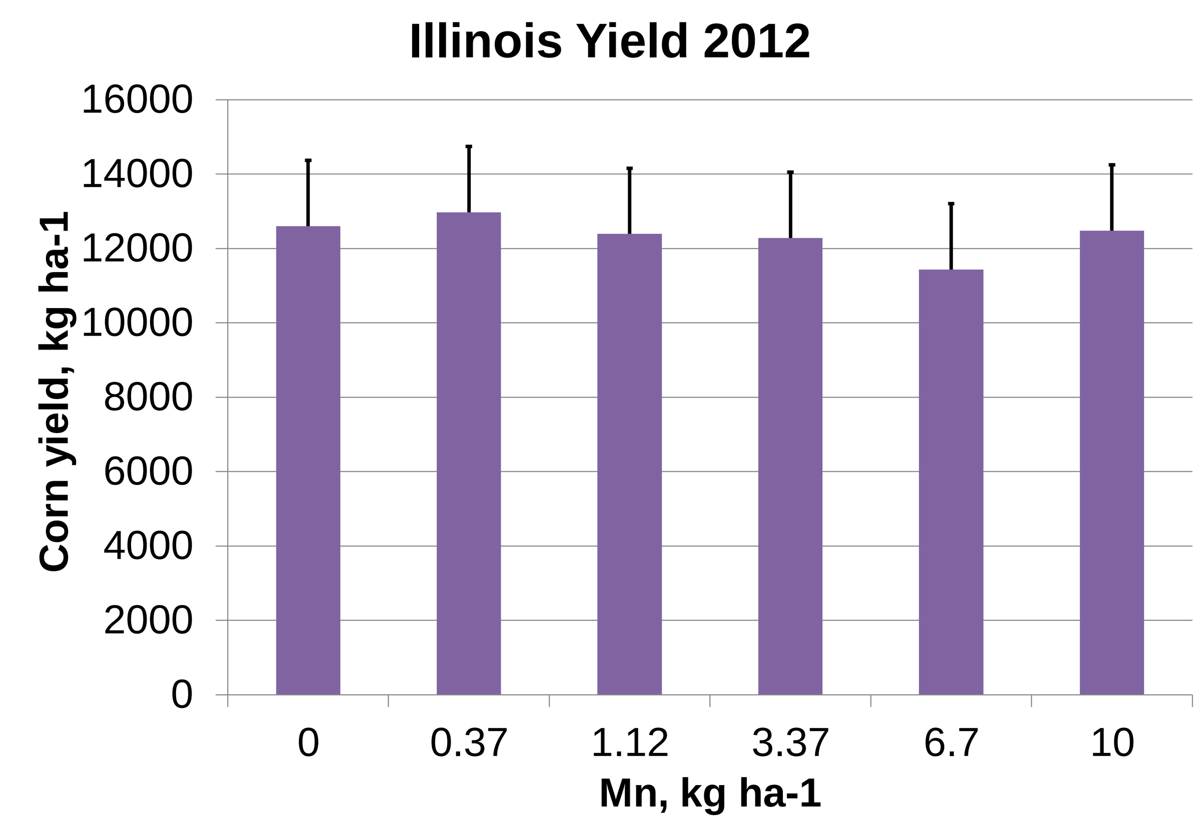

Figure 3. Corn yield as affected by Mn rate applied prior to planting on a Rozetta silt loam soil in Illinois.

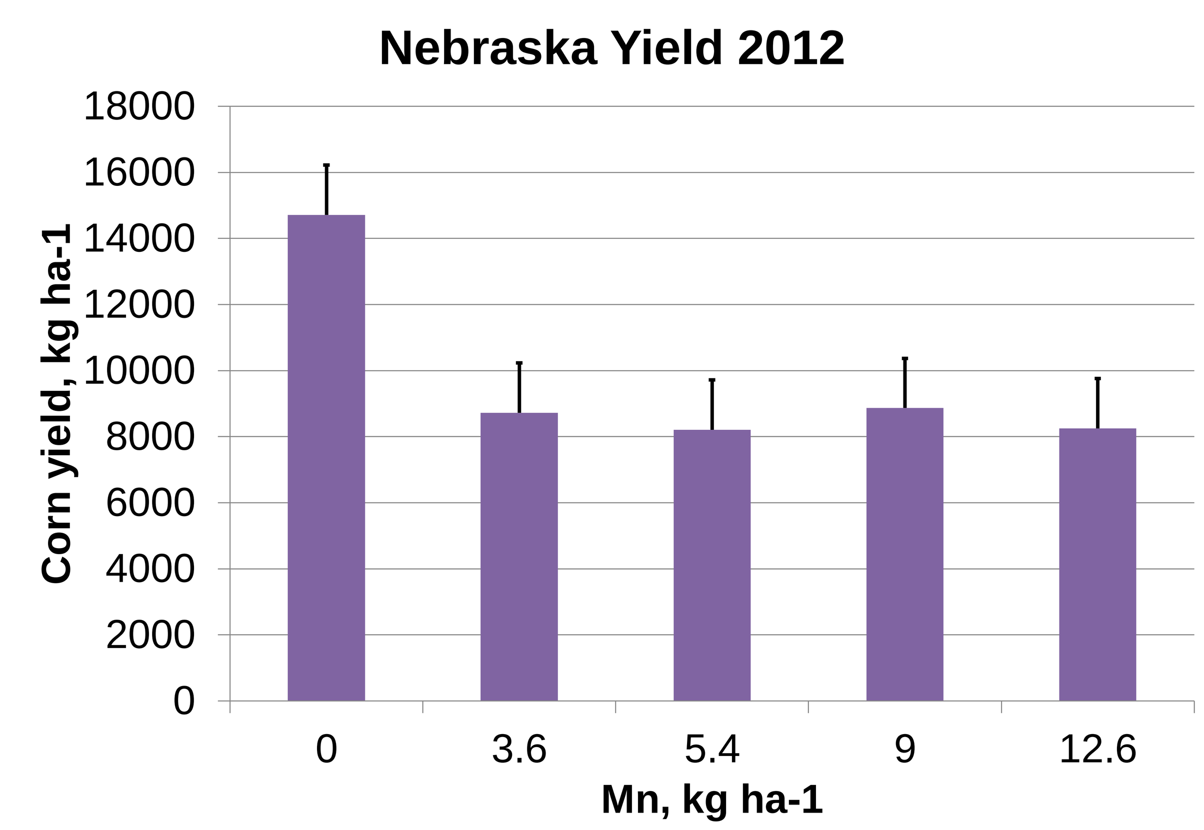

Figure 4. Corn yield as affected by Mn rate applied prior to planting on a Thurman loamy fine sand soil in Nebraska.

Discussion

- In the Nebraska, the soil had a more acidic pH and a low CEC (Table 3) which enabled more Mn to remain available for plant uptake. Increasing rates of Mn have been linked to reduced Magnesium (Mg) uptake (Table 1) and the presence of Mg deficiency symptoms such a reddening along the leaf edges and beading (necrotic spots) between the veins (Figure 2).
- In Illinois the soil in both locations had a neutral pH and moderate CECs (Table 3). Because of the pH much of the Mn was likely oxidized and adsorbed to the CEC, making it unavailable for plant uptake. In addition, the ratio of soil Mg to Mn was much greater than that observed in Nebraska and the relative plant uptake of Mg to Mn was not affected enough for plant growth to be affected.
- In the fields where toxic rates of Mn (8.3 kg ha^{-1}) were applied to low CEC, acidic soils, the following steps were taken to abate the negative effects and yields were restored to pre-Mn application levels: 1) Soils were limed to a pH of 7 to increase oxidation of Mn to plant unavailable forms; 2) Magnesium was applied to increase its concentration relative to Mn on the CEC; 3) Manure was applied to increase soil CEC; and 4) Soils were tilled to incorporate manure and Mg and to increase the oxidation of Mn.

Table 3. Soil analysis for experiment locations prior to Mn appl.

	Nebraska	Illinois 2012	Illinois 2013
Soil texture	Sandy Loam	Silt loam	Silt
Soil pH	6	6.8	6.9
Organic matter, %	2.2	2.5	2.4
CEC, meq/100g	6	14.4	15.0
Phosphorus, kg ha^{-1}	79	170	123
Potassium, kg ha^{-1}	336	336	280
Magnesium, kg ha^{-1}	237	696	706
Calcium, kg ha^{-1}	1669	4933	5337
Sulfur, ppm	100.9	34.7	27.2
Zinc, ppm	7.3	4.8	2.4
Manganese, ppm	4.3	62.8	69.1
Iron, ppm	13.5	215.2	109.9

Figure 5. Ear size as affected by Mn (top) and untreated (bottom) in Nebraska.

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