Foliar Fertilization of Corn in Northeast Iowa

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Foliar Fertilization for Corn in Northeast Iowa

By

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A creative component submitted to the graduate faculty in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Agronomy

Program of Study Committee:
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Andrew W. Lenssen

Iowa State University

Ames, Iowa

2018

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INTRODUCTION

Corn (*Zea mays* L.) is one of the most widely grown crops in the world and corn is the largest crop grown in Iowa. Iowa has very productive soils to grow this crop but some crop nutrients are deficient in many fields, and some nutrients need to be added in order to reach full yield potential. Seventeen different elements were shown to be essential to plant growth and development (Havlin et al., 2014). This study utilized nitrogen (N), phosphorus (P), and potassium (K), which are among a group known as macronutrients, and sulfur (S), which is among a group of nutrients referred to as secondary nutrients. The study also utilized several nutrients of a group known as micronutrients, which are needed in small amounts by plants but are critical for plant compounds or physiological processes and can have a large detrimental impact on yield if they are not available in sufficient amounts (Havlin et al., 2014; Mallarino et al., 2015). The study involved application of nutrients to corn foliage and, therefore, it is important to briefly review the most relevant previous research with foliar fertilization with emphasis on Iowa research.

In contrast to research on foliar fertilization of soybean (*Glycine max* L. Merr.), research on foliar fertilization for corn with macronutrients and secondary nutrients has been scarce in Iowa and the upper Midwest region. In Iowa specifically, Sawyer (2009) reviewed foliar applications of macronutrients for their effects on corn yield back into the 1970s and concluded that positive responses were not found. He stated that this was due, in part, to the inability to deliver the large amounts of required macronutrients by foliar application. Recent research in other states of the region with foliar application of N or nutrient mixtures showed no positive corn yield response, and sometimes foliar application resulted in a negative response (Shetley et al., 2009; Stammer and Ruiz Diaz, 2017).
Comprehensive reviews have addressed micronutrient functions in plants, differences between crops in demand and sensitivity to deficiencies, and conditions to which deficiencies are possible (Johnson and Fixen, 1990; Martens and Lindsay, 1990; Sims and Johnson, 1991; Mortvedt et al., 1991; Havlin et al., 2014). These authors indicated that plant-available levels of micronutrients in soils are influenced by soil mineralogy, texture, pH, organic matter, water content, nutrient interactions, and temperature among others. The concentrations in soil of other nutrients can also affect the availability of micronutrients to the plant. For example, a large amount of P present in the soil solution can decrease the availability and/or plant uptake of copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn), although this has not been the case in Iowa and the North Central region of the United States (Mallarino and Webb, 1995; Voss, 1998).

Documented micronutrient deficiencies in corn or soybean and published research including correlations between grain yield response and soil or tissue test methods from Iowa and neighboring states is scarce mainly due to predominant adequate sufficient levels in most soils. For this reason, few states have soil or tissue test interpretations for micronutrients, and most are general guidelines that recognize significant uncertainty due to scarce local research data. Iowa State University has recommendations only for Zn in corn and sorghum (Sorghum bicolor L. Moench) that are based on soil testing (Mallarino et al., 2013) and recommend Zn fertilization when results of the DTPA (diethylenetriamine-pentaacetic acid) soil test is less than 0.9 ppm (6-inch sampling depth). These recommendations were established in the early 1980s based on results of unpublished research during the 1960s and 1970s.

Research with corn in Iowa since the 1990s showed no yield response in most cases, however a few increases and decreases in yield were noted, from fertilization with micronutrients applied to the corn foliage or to the soil, which did not allow for updating or changing Iowa State
University recommendations. Mallarino and Webb (1995) summarized a 30-year experiment with continuous corn and showed no response to Zn applied to plots that received several P fertilization rates and had soil pH ranging from slightly acid to calcareous. Bickel and Killorn (2007) evaluated soil-applied Zn in several northern Iowa fields and reported isolated yield increases but more frequently yield decreases that were not related to soil-test Zn, soil pH, or the soil series. Mueller and Ruiz Diaz (2011) did not observe a corn yield response to foliar fertilization with various micronutrients in Kansas. Mallarino (2014) reported no corn yield increases or decreases from seven foliar fertilization trials with B, Cu, Mn, and Zn sprayed separately or in mixture and from 24 trials with B, Mn, and Zn applied to the soil separately or in a mixture. A summary of recent research with corn and soybean in Indiana, Iowa, Kansas, Minnesota, and Wisconsin reported a general lack of yield response to micronutrients with the exception of Mn in Indiana (Mallarino et al., 2015).

As corn yields have continued to increase growers have questioned the capacity of the soil to provide all the nutrients needed to maximize corn yield. One solution that has been offered is the application of a foliar fertilizer. As new foliar fertilizer products have come to market, not all of them have been tested for potential effects on corn yield. The objective of this creative component was to study the corn grain yield response to a foliar application of a fluid fertilizer containing a mixture of N, P, K, S, and six micronutrients in three northeast Iowa fields.
MATERIALS AND METHODS

The research was conducted in 2015 on three northeast Iowa farmers’ fields. The fields were chosen with growers willing to participate in the experiment. We carefully chose fields that would allow enough room for the experimental plot areas using the equipment available.

Field 1 and 2 were typical of non-manured farm fields in Floyd County. The predominant soil series was Ostrander loam [mesic Typic Endoaquoll] and Clyde silty clay loam [mesic Typic Hapludoll] respectively. Field 1 had been in a corn/soybean rotation for as long as the grower could remember. It had been in a grid soil sampling program (2.5 acre grids) for the last 16 years, and had received P and K fertilization using variable rate application based on the soil test results. The N fertilization program for 2015 consisted of 100 lb N/acre as anhydrous ammonia applied in the fall of 2014 with 1qt/acre of N-Serve® (nitrapyrin) and top-dressed during the summer with 46 lb N/acre of Super U®. Hybrid corn DKC 53-58 was planted 17 April. Field 2 had been in continuous corn for the last 10 years with the exception of 2013, when it was not planted due to excessive rainfall and was later seeded with a cover crop mixture of oats (Avena sativa L.) and radish (Raphanus sativus L). It has also been in a grid soil sampling program (2.5 acre grids) for the previous 16 years and received variable rate P and K fertilization based on the soil test results. The N fertilization program for 2015 was 100 lb N/acre as anhydrous ammonia applied in the fall of 2014 with 1 qt/acre of N-Serve added, an application of 30 lb N/acre as 28% UAN (urea-ammonium nitrate), and 46 lb N/acre of Super U was top-dressed in the summer. Hybrid corn FS 57QX1 was planted on May 3.

Field 3 was chosen to act as a “check” of sorts to this experiment. This field was owned by a grower with a large cattle feedlot. Manure was applied annually at about 20 ton/acre (as-is). With information that manure should contain micronutrients that would be available to the crop
as the manure is broken down, we would not expect a yield response to foliar fertilization. The predominant soil series was Wapsi loam [mesic Mollic Hapludalf]. This field also has been in a grid soil sample program (2.5 acre grids) for the previous eight years and P and K fertilization was variable rate applied based on the test results after accounting for available nutrients in the manure. The N fertilization program for 2015 included 120 lb N/acre as anhydrous ammonia in the spring of 2015 and 46 lb N/acre as Super U top-dressed in the summer. Corn was planted on April 30 using DKC 54-38 hybrid.

Table 1 shows the field averages of the soil test results, and the date in which, the fields were sampled for the last time prior to the 2015 crop year. On average, the three fields tested High to Very High in P and K according to Iowa State University soil test interpretations (Mallarino et al., 2013). The soil pH was near optimum (6.5) for soils in northeast Iowa, according to current recommendations (Mallarino et al., 2013)

<table>
<thead>
<tr>
<th>Field</th>
<th>pH</th>
<th>P</th>
<th>K</th>
<th>OM</th>
<th>CEC</th>
<th>Date of Last Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.4</td>
<td>37.1</td>
<td>226.1</td>
<td>5.2</td>
<td>15.9</td>
<td>11-11-2013</td>
</tr>
<tr>
<td>2</td>
<td>6.4</td>
<td>34.5</td>
<td>231.8</td>
<td>4.8</td>
<td>14.6</td>
<td>5-13-2014</td>
</tr>
<tr>
<td>3</td>
<td>6.6</td>
<td>99.7</td>
<td>248.7</td>
<td>4.8</td>
<td>12.8</td>
<td>10-10-2013</td>
</tr>
</tbody>
</table>

†P by the Mehlich-3 P method; K by the Mehlich-3 method on dried samples; OM, organic matter, by the loss on ignition method; CEC, cation exchange capacity estimated by the NCERA-13 summation method (Warncke and Brown, 1998).

A nutrient mixture was sprayed to the corn foliage and a control receiving no foliar fertilization. Treatments were arranged in a complete block design with strip trial methodology. The treatments were replicated six times at each field and were applied to three fields. The two treatments were applied to alternating long strips at each site to accommodate the six
replications. Individual plot width was 120 feet at each field but the length varied from 2300 feet to 490 feet long. The treatments were applied with a John Deere 4940 self-propelled sprayer with a 120-foot boom when the corn was at the V5 to V7 growth stage (Abendroth et al., 2011). The fertilizer was a tank mixture of Wuxal® Triple at a rate of 1 qt/acre and Wuxal® Zn at a rate of 1 pt/acre with a post application of herbicides. The Wuxal® is a suspension fertilizer, and both products were mixed in the applicator tank and applied simultaneously. The herbicides were Halex GT® (premix of mesotrione, S-metolachlor, and glyphosate) at 3.6 pt/acre, Infantry 4L® (atrazine) at 1 pt/acre, and FS Max Supreme® (an AMS adjuvant) at 0.375 gal/acre. The Wuxal fertilizer was used because of the mix of nutrients. Table 2 shows the nutrients in each.

<table>
<thead>
<tr>
<th>Product</th>
<th>Nutrient Concentration (%)</th>
<th>Amount of Nutrients Applied (lb/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wuxal Triple (1 qt/acre)</td>
<td>N 15.0, P₂O₅ 15.0, K₂O 15.0, S 1.10, B 0.02, Cu 0.05, Fe 0.05, Mn 0.001, Mo 0.0001, Zn 0.05</td>
<td>0.54, 0.47, 0.47, 0.03, 0.001, 0.002, 0.003, 0.002, 0.00003, 0.084</td>
</tr>
<tr>
<td>Wuxal Zinc (1 pt/acre)</td>
<td>N 5.0, P₂O₅ 6.00, K₂O 15.0, S 1.10, B 0.02, Cu 0.05, Fe 0.05, Mn 0.001, Mo 0.0001, Zn 0.05</td>
<td>0.54, 0.47, 0.47, 0.03, 0.001, 0.002, 0.003, 0.002, 0.00003, 0.084</td>
</tr>
</tbody>
</table>

The applicator was equipped with a GreenStar® 3 controller that was used to record the amounts applied and the georeferenced coordinates of the application. Once the fertilizer applications were completed, the information was downloaded from the controller into AgLeader’s SMS® software to be paired with the harvested yield data. At harvest time, growers calibrated their respective yield monitors and the georeferenced yield maps that they created.
were used to overlay onto the application data in SMS to obtain the yield for the strips with and without the fluid fertilizer applications. The growers had been using yield monitors for a long time and the harvest, as well as the yield and moisture recording with georeferenced coordinates, was done without problems. The yield data used for the study were unaffected by borders because the experimental areas were at least 120 feet away from field borders and the corn rows harvested were the same width to which the treatments were sprayed. The grain yield data was adjusted to 15% moisture content. The weather for 2015 was what most growers in the area would consider “ideal” for crop production. Many area farmers commented that 2015 was the best crop they had ever grown.

Once all the data analysis was done in SMS, yield data was input to SAS for the statistical analysis using a complete block design using the MIXED procedure of SAS. Analysis of variance were conducted for each site and across sites. Data were analyzed assuming a randomized complete-block design using PROC MIXED of SAS (SAS Inst., 2011) assuming fixed treatment effects and random site and block effects. Treatment means were compared to determine significance at the 0.05 level.
RESULTS AND DISCUSSION

Table 3 shows the corn grain yield results observed at each site and for the averages across the three sites. Foliar fertilization did not influence corn yield at Sites 1 and 2. At Site 3, however, there was a yield decrease from fertilization compared with the control that was statistically significant at the less rigorous 0.10 probability level that sometimes is used for field research. Results for yield across the three sites show that a yield reduction was statistically significant at the 0.05 probability level. The yield results can be better visualized in Fig. 1.

<table>
<thead>
<tr>
<th>Site</th>
<th>Control</th>
<th>Foliar Fertilizer</th>
<th>P&gt;F Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>229.3</td>
<td>229.9</td>
<td>0.828</td>
</tr>
<tr>
<td>2</td>
<td>225.0</td>
<td>219.3</td>
<td>0.173</td>
</tr>
<tr>
<td>3</td>
<td>215.1</td>
<td>201.7</td>
<td>0.070</td>
</tr>
<tr>
<td>Mean</td>
<td>223.1</td>
<td>217.0</td>
<td>0.026</td>
</tr>
</tbody>
</table>

Table 3. Corn grain yields and statistics for three sites treated with a foliar fertilizer in Iowa.
The interaction site by treatment in the analysis of variance across the three sites was significant at the 0.10 probability level (Table 4). A partition of the interaction using the SLICE option of the LSMEANS statement of SAS indicated that the fertilization reduced yield only at Site 3 where a yield decrease was significant at the 0.05 probability level (Table 4). Therefore, analyses of variance by site and across sites confirmed the 14 bu yield reduction by the fertilization at Site 3.

Table 4. F-test probability for the interaction sites by treatment in the analysis of variance for corn grain yield across three sites.

<table>
<thead>
<tr>
<th>Effect</th>
<th>$P&gt;F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site by treatment</td>
<td>0.095</td>
</tr>
<tr>
<td>Slice, Site 1</td>
<td>0.890</td>
</tr>
<tr>
<td>Slice, Site 2</td>
<td>0.227</td>
</tr>
<tr>
<td>Slice, Site 3</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Figure 1. Corn grain yield for each site and averages across the sites.
The results agree with previous results observed in Iowa and some states of the North Central region. A yield increase to the N, P, and K supplied by the fluid fertilizer was not expected given previous results and because all sites received fertilization that would have minimized the possibility of an additional yield increase. Although previous Iowa research with micronutrients has shown occasional corn yield responses only to Zn, we thought that a yield increase from some of the micronutrients or the S supplied would be possible. Unfortunately we could not do soil or tissue testing for micronutrients or sulfur, so we cannot make a supported statement concerning reasons for the observed lack of yield increases. We did not expect a yield decrease from the fertilization either, because the small rates applied to the foliage did not result in visible leaf damage. Therefore, the yield decrease from the application of this foliar fertilizer mixture at Site 3 is difficult to explain, and could have resulted from random variability or experimental error despite having used six replications.

As researchers of previous studies have stated, Iowa soils seem able to provide the amount of micronutrients needed by crops, and some micronutrients are applied from impurities in fertilizer, pesticides, and significant concentrations in animal manures (Voss, 1998; Mallarino and Webb, 1995; Bickel and Killorn, 2007; Mallarino, 2014). We know that one pool of micronutrients in the soil is in the soil organic matter, and that the weather conditions we have can have a very large impact on the speed of the breakdown of micronutrients (Voss, 1998). If we have conditions that are favorable for microorganism growth and reproduction we will have more organic matter breakdown and more release of nutrients, including micronutrients, that plants can absorb.

As seen in Figures 2 and 3 there was no deficient or excessive rainfall that could have led to very dry or saturated soil conditions for a long period of time, and temperatures seldom were
excessively hot during the growing season. There were only 8 days from May 3 to October 10, when the temperature was over 90 degrees F for part of the day. Cool saturated soils and dry soils are conditions that could induce deficiencies for some micronutrients (Voss, 1998). The precipitation and temperature information in Fig. 2 and 3 was obtained from the weather station at the Iowa State University Northeast Iowa Research and Demonstration Farm in Nashua, which is within 10 miles of all the trial sites.

Figure 2. Daily rainfall data from ISU Nashua Research Farm that is within 10 miles of the trial sites.
CONCLUSIONS

Foliar fertilization of corn with a fluid fertilizer product (Wuxal®) containing N, P, K, S, and several micronutrients did not increase grain yield at two sites, but it decreased yield at one site. The yield decrease at the one site could not be explained, and could have resulted from experimental variability. The results corroborated previous studies done in Iowa and other states of the North Central Region. The soils, management history, and growing conditions did not result in a deficiency of any of the nutrients supplied and therefore, the foliar fertilization did not increase corn yield.
REFERENCES


