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Evaluating the Effectiveness of Iron Chelates in Managing Iron Deficiency Chlorosis in Grain Sorghum

Abstract

Grain sorghum production in alkaline or calcareous soils is frequently affected by iron (Fe) chlorosis. Soil conditions such as high pH, high free calcium carbonate (lime), and low organic matter favor development of iron deficiency chlorosis (IDC), which can delay crop maturity and reduce yields. Two field experiments were conducted in the summer of 2014 to determine the effectiveness of Fe chelate application in alleviating IDC in grain sorghum. Treatments in the first study were four Fe chelate application rates (0, 3, 6, and 9 lb/a) applied either in-furrow with the seed at the time of planting or 2 weeks after planting. A split treatment of 3 lb/a applied at planting and another 3 lb/a applied 2 weeks after planting was included. The second study was a split-plot design with two Fe chelate products as main plots and sorghum hybrids (Golden Acres 5613 and Sorghum Partners hybrid NK5418) as the subplot factor. Results showed IDC scores among the treatments were significant only in the early stages of growth. Severity of IDC tends to decrease throughout the growing season, confirming the ability of sorghum hybrids to grow out of IDC under favorable environmental conditions. Iron chelate application did improve sorghum yield, with the highest yield occurring when Fe chelate was split-applied at 6 lb/a. The two grain sorghum hybrids evaluated differed in their response to IDC and grain yield. GA5613 showed greater tolerance to IDC than NK5418. Application of Fe chelate to GA5613 had no effect on grain yield; however, Fe chelate application significantly improved grain yields in NK5418. Our preliminary findings suggest the first 30 days of growth may be the critical period to control IDC in grain sorghum.

Keywords

grain sorghum, iron deficiency, chlorosis, iron chelates

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Evaluating the Effectiveness of Iron Chelates in Managing Iron Deficiency Chlorosis in Grain Sorghum

A. Obour and R. Perumal

Summary

Grain sorghum production in alkaline or calcareous soils is frequently affected by iron (Fe) chlorosis. Soil conditions such as high pH, high free calcium carbonate (lime), and low organic matter favor development of iron deficiency chlorosis (IDC), which can delay crop maturity and reduce yields. Two field experiments were conducted in the summer of 2014 to determine the effectiveness of Fe chelate application in alleviating IDC in grain sorghum. Treatments in the first study were four Fe chelate application rates (0, 3, 6, and 9 lb/a) applied either in-furrow with the seed at the time of planting or 2 weeks after planting. A split treatment of 3 lb/a applied at planting and another 3 lb/a applied 2 weeks after planting was included. The second study was a split-plot design with two Fe chelate products as main plots and sorghum hybrids (Golden Acres 5613 and Sorghum Partners hybrid NK5418) as the subplot factor. Results showed IDC scores among the treatments were significant only in the early stages of growth. Severity of IDC tends to decrease throughout the growing season, confirming the ability of sorghum hybrids to grow out of IDC under favorable environmental conditions. Iron chelate application did improve sorghum yield, with the highest yield occurring when Fe chelate was split-applied at 6 lb/a. The two grain sorghum hybrids evaluated differed in their response to IDC and grain yield. GA5613 showed greater tolerance to IDC than NK5418. Application of Fe chelate to GA5613 had no effect on grain yield; however, Fe chelate application significantly improved grain yields in NK5418. Our preliminary findings suggest the first 30 days of growth may be the critical period to control IDC in grain sorghum.

Introduction

Grain sorghum is susceptible to iron (Fe) deficiency chlorosis (IDC) when grown on high-pH soils in the Great Plains. High pH and free calcium carbonate associated with calcareous soils reduce the availability of Fe to the sorghum plant. This results in IDC with delayed crop maturity and reduced yields. The general approach to alleviating Fe deficiency in sorghum has been the application of foliar or soil amendments; however, these amendments have not been economically feasible on the field scale. Available Fe chelate products that are reported to correct Fe deficiency are too expensive to use on low-value field crops such as grain sorghum.

Several studies have attempted to develop alternative cheaper strategies for managing IDC in sorghum. These include breeding and selecting for Fe-efficient sorghum cultivars and application of Fe-containing fertilizer products.

Managing IDC is complicated by the temporal and spatial heterogeneity of IDC in sorghum fields. Heterogeneity in soil chemical composition within fields causes spatial development of IDC, which creates a major challenge to managing the problem on a field scale. An effective management strategy for preventing IDC in grain sorghum should be a comprehensive approach that considers soil heterogeneity, application of chelated Fe products, and selection of IDC-tolerant sorghum cultivars. Previous research has documented that in-furrow application of ortho-ortho-EDDHA Fe can reduce IDC in soybean and dry edible beans. Research extending this technology to managing IDC in grain sorghum has been limited. The objective of this study was to determine the effectiveness of ortho-ortho-EDDHA Fe chelate in preventing IDC in grain sorghum.

Procedures

Two experiments were conducted at a producer's field near Holcomb, KS, to evaluate the effectiveness of iron chelates in alleviating IDC in grain sorghum. Treatments in the first experiment were four Fe chelate application rates (0, 3, 6, and 9 lb/a) applied either in-furrow with the seed at the time of planting or two weeks after planting. A split application treatment of 3 lb/a applied at planting and another 3 lb applied 2 weeks after planting was included. In the second study, two sorghum hybrids that showed tolerance to IDC in the greenhouse were tested to evaluate their performance under field conditions. Treatments were two Fe chelate products as main plots and sorghum hybrids (Golden Acres 5613 and Sorghum Partners hybrid NK5418) as the subplot factor.

All plots received equal amounts of nitrogen (N) and phosphorus (P) applied at 100 and 30 lb/a, respectively. Before planting, three soil core samples were taken from 0- to 15-cm depths from individual plots (individual plots were 10 ft × 30 ft) and combined to form composite samples for each block. The samples were air-dried and analyzed for soil pH; electrical conductivity (EC); Mehlich-3 P; KCl-extractable NO_3-N and NH_4-N; NH_4OAC-extractable potassium (K), calcium (Ca), magnesium (Mg), and sodium (Na); DTPA-extractable Fe, zinc (Zn), Mg; and soil organic matter. Results of the initial soil analysis were 2.1% organic matter, pH 7.8, 14.5 mg/kg P, 611 mg/kg K, 4,888 mg/kg Ca, 383 mg/kg Mg, and 20 mg/kg nitrate-N. Similarly, Fe concentration was 3.6 mg/kg, Zn was 1.6 mg/kg, and Mn was 6.9 mg/kg. Calcium carbonate was 8.1%.

SPAD (chlorophyll meter) readings, IDC scores, and plant height information were taken 30 and 60 days after planting. The plots were harvested in mid-November to determined grain yield.

Results

Experiment 1

Results showed IDC scores among the treatments were significant only in the early stages of growth. Split application of Fe chelate at 6 lb/a suppressed IDC compared with the other chelate treatments (Table 1; Figure 1). At 60 days after planting, IDC was similar among the Fe chelate treatments. In general, the severity of IDC tends to decrease over the growing season, confirming the ability of sorghum hybrids to grow out of IDC under favorable environmental conditions. Similarly, relative chlorophyll content and plant height at 30 days after planting were greatest when 6 lb/a Fe chelate was split-applied. As the growing season progressed, no differences in SPAD values and plant height were observed among the treatments. Iron chelate application did improve sorghum yield compared with the control. The highest yield occurred when Fe chelate was split-applied at 6 lb product/a. Our preliminary results suggest the first 30 days of growth may be the critical period for controlling IDC to avoid yield suppressions.

Experiment 2

The two grain sorghum hybrids differed in their responses to IDC measured at 30 and 60 days after planting. At the beginning of the growing season, GA5613 showed greater tolerance to IDC than NK5418 (Table 2). The GA5613 checkplots had IDC scores similar to the Fe chelate-treated plots. Conversely, the application of Fe chelate suppressed IDC in NK5414, particularly during the first 30 days of growth (Table 2). Applying Soygreen (West Central, Inc., Willmar, MN) at 1.33 qt/a was effective in reducing IDC in NK5418. Relative leaf chlorophyll content tends to be greater in GA5613 at 30 days after planting. The greatest leaf chlorophyll content at 30 days after planting occurred when 3 g/a Redline (West Central, Inc., Willmar, MN) was applied to GA5613. Redline contains N and provides additional N to the treated plants, thus increasing leaf chlorophyll content. At 60 days after planting, however, leaf chlorophyll content was highest when 1.33 qt/a Soygreen was applied to NK5418.

Similar to IDC scores and leaf chlorophyll, grain yield response to Fe chelate treatments differed between the two hybrids. Applying Fe chelate to GA5613 had no effect on grain yield, but Fe chelate application significantly improved grain yields in NK5418 compared with the control. This preliminary finding suggests that GA5613 may be more tolerant to IDC than NK5418.

Table 1. Grain sorghum yield, iron (Fe) deficiency chlorosis (IDC) scores, and relative leaf chlorophyll content (SPAD) as affected by Fe chelate application

	IDC score		SPAD readings		
Fe chelate treatment	30 DAP[1]	60 DAP	30 DAP	60 DAP	Grain yield
					bu/a
Check	1.9	1.2	29.1	32.1	88.8
3 lb/a in-furrow	1.6	1.2	29.8	33.7	101.2
6 lb/a in-furrow	1.5	1.2	29.7	30.3	104.5
9 lb/a in-furrow	1.4	1.2	30.3	32.1	91.5
3 lb/a postemergence	1.6	1.2	31.0	34.6	106.5
6 lb/a postemergence	1.5	1.1	32.1	33.2	101.8
9 lb/a postemergence	1.6	1.2	31.5	33.4	109.5
6 lb/a split	1.1	1.1	37.4	33.9	109.8
Standard error	0.1	0.1	1.9	32.1	6.5

[1] Days after planting.

Table 2. Grain sorghum yield, iron (Fe) deficiency chlorosis (IDC) scores, and relative leaf chlorophyll content (SPAD) of two sorghum hybrids as affected by Fe chelate application

		IDC score				SPAD readings					
Fe chelate	Application	30 DAP[1]		60 DAP		30 DAP		60 DAP		Grain yield	
treatment	rate	GA5613	NK5418	GA5613	NK5418	GA5613	NK5418	GA5613	NK5418	GA5613	NK5418
										------ bu/a ------	
Check	0	1.0	1.6	1.7	1.8	27.4	26.2	39.7	37.4	101.5	82.5
Soygreen[2]	1.33 qt/a	1.3	1.0	1.8	1.6	30.1	28.5	39.3	46.5	107.8	92.3
Redline[3]	2 gal/a	1.0	1.3	1.6	1.9	27.8	27.9	42.8	44.7	95.3	101.3
Redline	3 gal/a	1.2	1.3	1.4	1.8	31.3	25.2	39.3	39.1	91.5	93.6
Standard error		0.2	0.2	0.2	0.2	2.1	2.1	2.3	2.3	6.2	6.2

[1] Days after planting.
[2] West Central, Inc., Willmar, MN.
[3] West Central, Inc., Willmar, MN.

Figure 1. The control treatment (left) and a plot that received 6 lb/a iron chelate (right) show the difference between treatments. Photos were taken on July 18, 2014 (30 days after planting).