FOLIAR FERTILIZER AND FUNGICIDE INTERACTIONS ON CORN

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Corn acreage increased over 25% in Missouri and total acreage in the U.S. increased nearly 10 million acres from 2006 to 2007. High yield corn production systems have integrated fungicide applications to maximize photosynthetic efficiency of the plant. Over the past four years, median corn yields for 16 site/years increased over 8 bu/acre with a strobilurin fungicide such as pyraclostrobin (Headline®) (Nelson and Smoot, 2007). The greatest yield increases due to fungicide applications have occurred in high yield environments.

Fungal infections decrease the area of photosynthetic tissue which reduces the transfer of assimilates from their source to the ear and diverts assimilates to fungal growth, defense systems, and increased respiration. Growth stimulation with the strobilurin fungicides has been related to a reduction in the incidence of disease as well as increased nitrate uptake and assimilation in small grains (Köhle et al., unpublished). Research has shown that pyraclostrobin was important in stimulating nitric oxide, a key messenger in plants (Conrath et al., 2004). Increased nitrate uptake and assimilation following an application of a strobilurin fungicide would justify additional fertilizer at the time of application. Identifying fertilizer sources that synergistically increase yield with a fungicide treatment would provide opportunities to manage disease, reduce application costs, and provide additional fertilizer when crop demand is greatest.

Research has established a link between plant nutrition and disease incidence including the disease suppressing effects of K, Cl, Mn, B, and P (Fixen et al, 2004). Combining a foliar fertilizer with a fungicide application may reduce application costs, improve disease suppression and nutrient response, and increase flexibility in managing crop response to environmental conditions during the growing season. There was a dramatic increase in the use of strobilurin fungicides in corn in 2007; however, no research has evaluated interactions between fertilizer sources and a fungicide treatment. This research will help Missouri farmers make informed decisions regarding fungicide-fertilizer interactions and how these applications affect productivity and profitability. No published research has evaluated interactions between fungicides and foliar fertilizers on corn. No research has been published on the effects of fungicide treatments on corn plant nutrient levels in the field.

The objective of this research is to evaluate improvements in yield and monitor nutrient uptake of a foliar fertilizer-fungicide management system for corn.

Materials and Methods:
The first of a two-year field trial was conducted under sprinkler irrigation at Novelty (40.035997 N, 92.243783 W) and Albany (40.251282 N, 94.326977 W) while at Portageville (36.427945 N, 89.700234 W) corn was flood irrigated to assess corn response to fungicide-fertilizer treatments in high yield environments. The soil was a Putnam silt loam (fine, smectitic, mesic Vertic

Albaqaulfs), Grundy silt loam (fine, montmorillonitic, mesic Aquic Argiudolls), and Tiptonville sandy loam (fine-silty, mixed, thermic Typic Argiudolls) at Novelty, Albany, and Portageville, respectively. Field information about the locations and selected management practices is shown in Table 1.

The study was randomized complete block design with five, four, and three replications at Novelty, Portageville, and Albany, respectively. Treatments consisted of a factorial arrangement of foliar fertilizers combined with and without the fungicide pyraclostrobin (Headline®) at 6 oz/acre plus nonionic surfactant at 0.25% v/v applied at VT. Treatments were applied with a CO_2 propelled hand boom at 3 gallons/acre to simulate an aerial application. The following fertilizer treatments and rates were selected for this research based on previous experience and locally available foliar fertilizers used on corn in combination with fungicide treatments: 3-18-18-0 (%N-%P_2O_5-%K_2O-%S) at 2 gal/acre (NA-CHURS/ALPINE Solutions, Marion, OH), 0-0-30-0 at 2 gal/acre (Double-OK, NA-CHURS/ALPINE Solutions, Marion, OH), potassium thiosulfate (0-0-25-17) at 1 gal/acre (KTS, Tessenderlo Kerley Inc., Phoenix, AZ), potassium thiosulfate plus urea triazone (5-0-20-13) at 1.5 gal/acre (Trisert K+, Tessenderlo Kerley Inc., Phoenix, AZ), potassium chloride (0-0-62-0) at 2.5 lb/acre (PCS, Potash Corp. of Saskatchewan, Northbrook, IL), 25-0-0-0 controlled release nitrogen as methylene urea and diurea with less than 0.01% Cl at 3 gal/acre (CoRoN, Helena Chemical Co., Collierville, TN), 24-0-1-0.6 slow release N with 0.25% B at 3 gal/acre (Pacer N, Crop Production Services, Galesburg, IL), 22-0-2-1 with 0.25% B at 1 gal/acre (Task Force Maize, Crop Production Services, Galesburg, IL), 30-0-0-0 at 1 gal/acre (Nitamin, Georgia-Pacific Chemicals, LLC., Atlanta, GA), boron at 2 pt/acre (NA-CHURS/ALPINE Solutions, Marion, OH), Mn-chelate at 2 pt/acre (NA-CHURS/ALPINE Solutions, Marion, OH), Fe-Mo-Mn-B-Zn (0.3%-0.01%-3.2%-0.2%-2.1%) premix at 1 qt/acre (MAX-IN, Winfield Solutions, LLC., St. Paul, MN), and 6-0-0-0 with 10% Ca at 2.5 gal/acre (Nutri-Cal, CSI Chemical Corp., Bondurant, IA

Corn injury from 0 (no visual crop injury) to 100% (complete crop death) was evaluated 7 to 14 days after treatment based on the combined visual effects of N source on necrosis, chlorosis, and stunting. The incidence of foliar disease was rated on a scale of 0 (no disease) to 100% (complete infestation) 28 days after treatment. Ear leaf tissue status of the fungicide-treated and untreated plants was intensively monitored at each location from the time of application until black layer to build background information to target synergistic foliar nutrient applications. Analysis of corn ear leaf tissue was monitored 7 days after application for all treatments. Leaf tissue samples are currently being analyzed.

The center two rows were harvested for yield and moisture converted to 15% prior to analysis. Grain samples were collected. Grain protein, oil and starch will be determined using NIR spectroscopy from the Portageville and Novelty sites. Data were subjected to an analysis of variance and means separated using Fisher's Protected LSD at $P \leq 0.05$. Main effects were presented in the absence of interactions.

Results:

The incidence of disease was less than 5% at Novelty, Portageville, and Albany in 2008 (Tables 2 and 3). There was a slight reduction in the incidence of grey leaf spot at Albany with pyraclostrobin, but no other effects due to the fungicide were detected (Table 2). There was a greater incidence of grey leaf spot when 0-0-30-0 and 0-0-25-17 was applied at Portageville when compared to the non-treated control. Similarly, 24-0-1-0.6 had a greater incidence of common rust at Albany when compared to the non-treated control. In general, there were minimal effects of the fungicide pyraclostrobin or fertilizer treatments on the incidence of diseases at Novelty, Portageville, or Albany in 2008.

The presence of foliar injury was primarily persistent necrosis of leaf tissue caused by fertilizer treatments. Injury was less than 10% for all treatments (Tables 4 and 5). Pyraclostrobin alone did not injure corn (data not presented). Foliar injury increased 0.3 to 0.5% at Novelty and Portageville with pyraclostrobin, but there was no effect of pyraclostrobin on injury at Albany (Table 2). Increased injury with pyraclostrobin was probably due to the presence of surfactant which increased foliar uptake of the fertilizer treatment. Crop injury with 0-0-30-0 ranged from 2 to 7% at all three locations (Table 5). Crop injury was inconsistent with other foliar fertilizers among locations with less than 10% injury with 0-0-25-17 at Novelty, 5-0-20-13 at Novelty, 6-0-0-0 at Portageville, and 22-0-2-1 at Albany.

Grain moisture was 0.3 to 0.4% greater when pyraclostrobin was applied when compared to the non-treated control at Novelty and Albany (Table 4). Fertilizer treatments such as 24-0-1-0.6 and a premix of Fe-Mo-Mn-B-Zn increased grain moisture 0.8 to 1.1% when compared to the non-treated control at Portageville (Table 5).

Pyraclostrobin increased grain yield 11 bu/acre at Novelty and Portageville in high yield environments (Table 4). None of the foliar fertilizer treatments increased grain yield when compared to the non-treated control (Table 5). A reduction in grain yield with 0-0-25-17 at Novelty and 6-0-0-0 at Portageville was related to foliar injury specific to the fertilizer treatments. Albany had a lower grain yield potential and grain yields were reduced with 3-18-18-0, 6-0-0-0, B, and a premix of Fe-Mo-Mn-B-Zn when compared to the non-treated control. Tissue analysis is currently underway.

Summary:

- The incidence of disease was less than 5% at all three locations and the effect of pyraclostrobin on disease was minimal.
- The incidence of disease was not affected by fertilizer treatments at Novelty or Albany while there was an inconsistent effect of fertilizer treatments on the incidence of disease at Portageville.
- Pyraclostrobin increased grain moisture 0.3 to 0.4% and yield 11 bu/acre when compared to the non-treated control at 2 of the 3 sites.
- There was no significant increase in grain yield when foliar fertilizers were applied to corn at VT. Some foliar fertilizers reduced grain yield 14 to 24 bu/acre when compared to the non-treated control in 2008.

References:

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Table 1. Field information and selected management practices in 2008.

Field information and management practices	Novelty	Portageville	Albany
Previous crop	Corn	Soybean	Soybean
Planting date	May 19	May 1	May 21
Fertilizer rate (N-P-K lbs/acre)	230-70-100	160-0-0	160-60-80
Hybrid	DK63-42	P33N58	DK62-43
Seeding rate (seeds/acre)	35,000	35,000	28,000
Fungicide and foliar fertilizer application date	July 23	July 9-10	July 16
Air temperature (F)	79	76	89
Relative humidity (%)	50	80	70
Height (inches)	96	120	120
Harvest date	October 10	September 22	November 21
Soil test information			
P (lbs/acre)	35	34	62
K (lbs/acre)	288	195	234
pHs	6.0	6.2	5.8
CEC (meq/100g)	14.9	9.7	18.8
Mg (lbs/acre)	367	189	696
Ca (lbs/acre)	3601	3052	5235
OM (%)	2.0	1.3	2.6

Table 2. Incidence of disease at Novelty, Portageville, and Albany 28 days after treatment in 2008. Data were combined over fertilizer treatments.

Fungicide	Novelty			Portageville		Albany	
Treatment	GLS[a]	CR	NCLB	GLS	ANTH	GLS	CR
	%						
Non-treated	1	0.2	0.1	1.2	1	0.2	2.5
Pyraclostrobin[b]	1	0.2	0	1.1	1	0	2.4
LSD (P≤0.05)	NS	NS	NS	NS	NS	0.1	NS

[a]Abbreviations: ANTH, Anthracnose (*Colletotrichum graminicola*); CR, common rust (*Puccinia sorghi*); GLS, grey leaf spot (*Cercospora zeae-maydis*); LSD, least significant difference; NCLB, northern corn leaf blight (*Exserohilum turcicum*); and NS, non-significant.
[b]Headline at 6 oz/acre plus non-ionic surfactant at 0.25% v/v.

Table 3. Incidence of disease at Novelty, Portageville, and Albany 28 days after treatment in 2008. Data were combined over fungicide treatments.

	Novelty			Portageville		Albany	
Fertilizer treatment[a]	GLS[b]	CR	NCLB	GLS	ANTH	GLS	CR
	%						
Non-treated	1	0.3	0	1	1.3	0	2.3
3-18-18-0	1	0.2	0	1	1	0	3
0-0-30-0	1	0.1	0	1.7	1	0.1	2.4
22-0-2-1, 0.25% B	1	0.1	0	1	1	0.3	2.8
24-0-1-0.6, 0.25% B	1	0	0.1	1.2	1	0.2	4.2
25-0-0-0, 0.01% Cl	1	0.6	0	1	1	0.2	2.4
0-0-25-17	1	0.3	0	1.7	1	0.1	1.6
5-0-20-13	1	0.1	0	1.2	1	0.1	2.4
0-0-62-0	1	0.4	0	1	1	0.1	3
30-0-0-0	1	0.2	0	1	1	0.2	2.5
6-0-0-0, 10% Ca	1	0.1	0.1	1	1	0	1.8
Boron	1	0.1	0.1	1.2	1	0	2.1
Fe-Mo-Mn-B-Zn	1	0.1	0.1	1	1	0	1.7
Mn-chelate	1	0.4	0	1	1	0	2.2
LSD (P≤0.05)	NS	NS	NS	0.3	0.2	NS	1.7

[a]3-18-18-0 (%N-%P_2O_5-%K_2O-%S) at 2 gal/acre (NA-CHURS/ALPINE Solutions, Marion, OH), 0-0-30-0 at 2 gal/acre (Double-OK, NA-CHURS/ALPINE Solutions, Marion, OH), potassium thiosulfate (0-0-25-17) at 1 gal/acre (KTS, Tessenderlo Kerley Inc., Phoenix, AZ), potassium thiosulfate plus urea triazone (5-0-20-13) at 1.5 gal/acre (Trisert K+, Tessenderlo Kerley Inc., Phoenix, AZ), potassium chloride (0-0-62-0) at 2.5 lb/acre (PCS, Potash Corp. of Saskatchewan, Northbrook, IL), 25-0-0-0 controlled release nitrogen as methylene urea and diurea with less than 0.01% Cl at 3 gal/acre (CoRoN, Helena Chemical Co., Collierville, TN), 24-0-1-0.6 slow release N with 0.25% B at 3 gal/acre (Pacer N, Crop Production Services, Galesburg, IL), 22-0-2-1 with 0.25% B at 1 gal/acre (Task Force Maize, Crop Production Services, Galesburg, IL), 30-0-0-0 at 1 gal/acre (Nitamin, Georgia-Pacific Chemicals, LLC., Atlanta, GA), boron at 2 pt/acre (NA-CHURS/ALPINE Solutions, Marion, OH), Mn-chelate at 2 pt/acre (NA-CHURS/ALPINE Solutions, Marion, OH), Fe-Mo-Mn-B-Zn (0.3%-0.01%-3.2%-0.2%-2.1%) premix at 1 qt/acre (MAX-IN, Winfield Solutions, LLC., St. Paul, MN), and 6-0-0-0 with 10% Ca at 2.5 gal/acre (Nutri-Cal, CSI Chemical Corp., Bondurant, IA).
[b]Abbreviations: ANTH, Anthracnose (*Colletotrichum graminicola*); Bacterial stalk ; CR, common rust (*Puccinia sorghi*); GLS, grey leaf spot (*Cercospora zeae-maydis*); LSD, least significant difference; NCLB, northern corn leaf blight (*Exserohilum turcicum*); and NS, non-significant.

Table 4. Corn injury 7 to 14 days after treatment, grain moisture, and yield as affected by pyraclostrobin at Novelty, Portageville, and Albany in 2008. Data were combined over fertilizer treatments.

Fungicide	Novelty			Portageville			Albany		
Treatment	Injury	Moisture	Yield	Injury	Moisture	Yield	Injury	Moisture	Yield
	%	%	Bu/a	%	%	Bu/a	%	%	Bu/a
Non-treated	1.7	19.5	216	1.6	17.1	159	0.5	15.9	143
Pyraclostrobin[a]	2.2	19.9	227	1.9	17.2	170	0.5	16.2	143
LSD ($P \leq 0.05$)[b]	0.5	0.2	6	0.2	NS	7	NS	0.2	NS

[a]Headline at 6 oz/acre plus non-ionic surfactant at 0.25% v/v.
[b]Abbreviations: LSD, least significant difference; and NS, non-significant.

Table 5. Corn injury 7 to 14 days after treatment, grain moisture, and yield as affected by fertilizer treatments at Novelty, Portageville, and Albany in 2008. Data were combined over fungicide treatments.

	Novelty			Portageville			Albany		
Fertilizer treatment[a]	Injury	Moisture	Yield	Injury	Moisture	Yield	Injury	Moisture	Yield
	%	%	Bu/a	%	%	Bu/a	%	%	Bu/a
Non-treated	0	19.4	222	0	17.0	170	0	16.0	151
3-18-18-0	0	19.8	226	0	16.9	174	0	16.0	132
0-0-30-0	7	19.6	211	2	17.6	153	5	16.4	144
22-0-2-1, 0.25% B	0	19.5	226	0	16.9	174	2	16.1	151
24-0-1-0.6, 0.25% B	0	19.8	217	0	18.1	158	0	16.1	152
25-0-0-0, 0.01% Cl	0	19.7	223	0	16.7	167	0	16.4	158
0-0-25-17	10	19.6	208	0	16.7	171	0	16.2	147
5-0-20-13	9	19.9	222	0	17.1	182	0	16.0	142
0-0-62-0	0	19.4	220	0	17.3	164	0	15.9	146
30-0-0-0	0	19.6	220	0	17.1	168	0	15.8	142
6-0-0-0, 10% Ca	1	19.6	221	1	17.1	149	0	15.9	136
Boron	0	20.0	234	0	17.1	161	0	16.1	133
Fe-Mo-Mn-B-Zn	0	19.8	226	0	17.8	159	0	15.9	127
Mn-chelate	0	19.6	223	0	17.1	161	0	15.9	139
LSD ($P \leq 0.05$)[b]	1.3	NS	14	0.5	0.5	19	1	NS	13

[a]3-18-18-0 (%N-%P_2O_5-%K_2O-%S) at 2 gal/acre (NA-CHURS/ALPINE Solutions, Marion, OH), 0-0-30-0 at 2 gal/acre (Double-OK, NA-CHURS/ALPINE Solutions, Marion, OH), potassium thiosulfate (0-0-25-17) at 1 gal/acre (KTS, Tessenderlo Kerley Inc., Phoenix, AZ), potassium thiosulfate plus urea triazone (5-0-20-13) at 1.5 gal/acre (Trisert K+, Tessenderlo Kerley Inc., Phoenix, AZ), potassium chloride (0-0-62-0) at 2.5 lb/acre (PCS, Potash Corp. of Saskatchewan, Northbrook, IL), 25-0-0-0 controlled release nitrogen as methylene urea and diurea with less than 0.01% Cl at 3 gal/acre (CoRoN, Helena Chemical Co., Collierville, TN), 24-0-1-0.6 slow release N with 0.25% B at 3 gal/acre (Pacer N, Crop Production Services, Galesburg, IL), 22-0-2-1 with 0.25% B at 1 gal/acre (Task Force Maize, Crop Production Services, Galesburg, IL), 30-0-0-0 at 1 gal/acre (Nitamin, Georgia-Pacific Chemicals, LLC., Atlanta, GA), boron at 2 pt/acre (NA-CHURS/ALPINE Solutions, Marion, OH), Mn-chelate at 2 pt/acre (NA-CHURS/ALPINE Solutions, Marion, OH), Fe-Mo-Mn-B-Zn (0.3%-0.01%-3.2%-0.2%-2.1%) premix at 1 qt/acre (MAX-IN, Winfield Solutions, LLC., St. Paul, MN), and 6-0-0-0 with 10% Ca at 2.5 gal/acre (Nutri-Cal, CSI Chemical Corp., Bondurant, IA).
[b]Abbreviations: LSD, least significant difference; and NS, non-significant.