FUNGICIDE AND SLOW-RELEASE NITROGEN COMBINATIONS FOR CORN

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Introduction:
High yield corn production systems have integrated fungicide applications to maximize photosynthetic efficiency of the plant. A relatively new class of fungicides, first available in 1996, are the strobilurin fungicides (Bartlett et al., 2002). In a study conducted from 2003-2007, median corn grain yields increased over 8 bu/acre with a strobilurin fungicide, such as pyraclostrobin (Headline®) (Nelson and Smoot, 2007). The largest grain yield increases due to fungicide applications have occurred in high yield environments where there were few growth limiting factors.

Increases in corn grain yield due to pyraclostrobin seem to come from a variety of different factors. The most direct reason for increased yields is the reduction of foliar diseases. Fungal pathogens, such as grey leaf spot (*Cercospora zea-maydis*), can cause severe yield losses and even complete failure of a crop (Ward and Nowell, 1998). Fungal pathogens colonize leaf tissue and often damage the leaves themselves. Necrotic damage to the leaf can drastically reduce the photosynthetic area and efficiency of the plant. Reduced photosynthesis results in less production of carbohydrates by the plant, and ultimately less productive plants and lower yields. In addition to reducing photosynthesis, fungal infections reduce the overall physiological efficiency of the plant by redirecting plant products and photoassimilates from producing and filling grain to fungal development, growth, metabolism, and reproduction, plant defense reactions, and respiration of the lesioned tissue (Venancio et al., 2003).

Yield increases after application of pyraclostrobin have also been attributed to physiological impacts other than disease suppression. This hypothesis arose after increases in yield were noted compared to other disease management programs even though there was no visible difference in disease control (Bartlett et al., 2002). Pyraclostrobin may directly alter many different physiological processes within the plant (Venancio et al., 2003). Physiological plant growth stimulation with the strobilurin fungicides has been related to increased nitrate uptake and assimilation in small grains (Köhle et al., 2002). 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 nitrogen fertilizer at the time of application to corn.

In a previous study in 2008 and 2009 evaluating interactions between Headline and a variety of foliar fertilizers, Nitamin (slow-release liquid N) was the only foliar fertilizer to significantly increase yield at Portageville and Novelty. Other foliar fertilizers resulted in greater amounts of damage and no additional disease control or yield increase during this research.

The objectives of this research were to evaluate response of corn to Nitamin (Georgia-Pacific Chemicals, LLC., Atlanta, GA) rates and Nitamin tank mixtures with Headline, and to determine the mixing order of Headline and Nitamin on crop response.

Materials and Methods:
Field research was conducted at Novelty (40.035997 N, 92.243783 W), MO in 2008 and 2009 with above average rainfall in both years. The soil was a Putnam silt loam (fine, smectitic, mesic Vertic Albaqaulfs). The study was a randomized complete block in plots 10 by 40 ft with four replications. Treatments consisted of a factorial arrangement of Nitamin (30-0-0) at 0, 0.5, 1, 2, and 4 gal/acre combined with and without the fungicide pyraclostrobin (Headline®) at 6 oz/acre plus nonionic surfactant (NIS) at 0.25% v/v applied at VT. Additional treatments of Headline at 3 oz/acre plus NIS at 0.25% v/v plus Nitamin at 1 gal/acre, and the mixing order of Headline at 3 and 6 oz/acre plus NIS plus Nitamin at 1 gal/acre were included in the study. Field information is shown in Table 1.

Foliar N fertilizer and fungicide treatments were applied with a CO_2 propelled hand boom at 5 gal/acre. Corn plants were exhibiting some N deficiency from V6 to VT; however, no additional N was applied to evaluate the benefit of foliar applied N at VT. Corn injury from 0 (no visual crop injury) to 100% (complete crop death) was evaluated 7 and 14 days after treatment (DAT) 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 DAT in 2008, 28 DAT in 2009, and 42 DAT in 2009. A Minolta chlorophyll meter (SPAD-502) was used 49 DAT to determine ear leaf greenness differences among treatments in 2009. Overall plant greenness was rated on a scale of 0 (brown) to 10 (green) on 28 Sept. 2008 and 2009. The center two rows were harvested for yield and converted to 15% moisture prior to analysis. Data were subjected to an analysis of variance and means separated using Fisher's Protected LSD at $P < 0.05$.

Results:
Harvested plant population was similar for all treatments and ranged from 26,400 to 30,200 plants/acre in 2008 (Table 2) or 2009 (Table 3). Prior to the foliar application, spray solution pH was determined as Nitamin and Headline were added. Solution pH was reduced with the addition of Headline alone while solution pH increased with the addition of Nitamin (Table 3). Solution pH with Nitamin was reduced 0.2 to 0.7 when Headline was tank mixed. The solution pH was lower when Headline at 3 oz/acre was added first followed by Nitamin at 1 gal/acre compared to when Nitamin at 1 gal/acre was added first followed by Headline at 3 oz/acre.

Crop injury increased 2 to 5% when Headline plus NIS was added to Nitamin at 2 to 4 gal/acre in 2008 (Table 2) or 2009 (Table 3). Injury was primarily localized necrosis of leaf tissue (Figures 1 and 2). There was a low incidence of disease and no difference in the incidence of disease was observed between the non-treated control and Nitamin or Headline treatments (Tables 2 and 3). Headline at 6 oz/acre plus Nitamin treated plants were greener prior to harvest. Similarly, grain moisture was 1.6 to 2.4% greater when Headline was applied alone or with Nitamin at 1 to 4 gal/acre when compared to the non-treated control in 2008 (Table 2), but not in 2009 (Table 3). The chlorophyll meter indicated that Nitamin at 4 gal/acre with and without Headline was greener than the non-treated control (Table 3). Although Nitamin at 1 gal/acre plus

Headline at 3 oz/acre was greener than Headline at 3 oz/a plus Nitamin at 1 gal/acre, grain yield was inversely related in 2009 (Table 3).

In 2008, grain yield increased 19 and 28 bu/acre when Nitamin was applied at 2 and 4 gal/acre, respectively (Figure 1) while yields increased 15 to 20 bu/acre when Nitamin was applied at 1 to 4 gal/acre in 2009 (Figure 2). There was no significant increase in grain yield when Nitamin was tank mixed with Headline at 6 oz/acre in 2008 or 2009; however, Headline at 3 oz/acre plus Nitamin at 1 gal/acre increased yield 23 bu/acre in 2008. A reduced rate of Headline (3 oz/acre) and Nitamin (1 gal/acre) had grain yields similar to Nitamin at 2 or 4 gal/acre alone or tank mixed with Headline at 6 oz/acre in 2008 and 2009. In years with N deficiency that was probably related to N loss due to wet conditions, Nitamin alone at 2 to 4 gal/acre increased yield while the combination of Headline and Nitamin was additive only at a reduced rate of both products which appears to be related to the mixing order of Headline and Nitamin.

Summary:

- Mixing sequence has an effect on corn response to Headline and Nitamin.
- Nitamin with and without Headline increased plant greenness.
- Mixing of Headline at the label rate of 6 oz/acre with Nitamin did not result in significant grain yield increases.
- Reduced rates of Headline mixed with Nitamin had greater increases of grain yield.
- Nitamin may be a valuable tool for addressing in season nitrogen challenges.

Current Research:

In years when N fertilizer loss has been suspected, a late application of reduced rates of the N fertilizer and fungicide has increased yield 26 bu/acre depending on the mixing order. Enhanced efficiency liquid N application has shown that yield increased 2 bu/acre for every pound of applied liquid N when the fertilizer was applied alone. The yield response appears to be related to the mixing order of the fertilizer additive. A clear understanding of these interactions is needed to help producers make an informed decision on the utilization of such pesticide/fertilizer combinations.

Current field trials are targeted at confirming effects of the mixing order of Nitamin and Headline, as well as developing recommendations for foliar N fertilizer application based on plant greenness measured using a chlorophyll meter. A factorial arrangement of four rates of preplant N fertilizers (0, 75, 150, and 300 lbs N/a) and three Nitamin rates (0, 1, and 3 gal/acre) in the presence or absence of Headline at 3 or 6 oz/acre either added prior to or following the addition of Nitamin to the spray mixture was initiated in 2010 at Albany and Novelty. Understanding when an additive and/or fungicide is needed and the expected returns is essential for recommending an enhanced efficiency liquid N fertilizer as part of an integrated crop management system. Basing enhanced efficiency liquid N fertilizer applications on SPAD readings at silking will help in the decision making process to include or exclude a fertilizer additive and help determine an economical rate of the additive.

References:

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Table 1. Field information and management practices at Novelty, MO in 2008 and 2009.

Field information and management practices	2008	2009
Previous crop	Corn	Soybean
Tillage	No-till	No-till
Planting date	May 20	April 22
Weed control		
Burndown	Roundup PowerMAX 22 oz/acre (April 28)	Roundup PowerMAX 22 oz/a + Bicep II Magnum 2.5 qt/a (May 4)
Preemergence	Lumax at 3 qt/acre (May 23)	Atrazine at 1 qt/a + Roundup OriginalMAX 28 oz/a (June 9)
Fertilizer rate (N-P-K lbs/acre)	200-0-0 (ESN)	180-0-0 (Am. Nitrate)
Hybrid	DK 63-42VT3	DK 63-42VT3
Seeding rate (seeds/acre)	30,800	30,800
Fungicide and foliar fertilizer application date	July 29	July 10
Air temperature (F)	95	86
Relative humidity (%)	63	75
Height (inches)	72	78
Harvest date	October 13	September 29

Table 2. Plant population, injury 14 d after treatment (DAT), incidence of disease (grey leaf spot and common rust) 28 DAT, greenness (1=brown to 10=green), and grain moisture as affected by Nitamin (30-0-0) alone and with Headline in 2008.

Treatment[a]	Rate	Population	Injury	GLS	CR	Greenness	Moisture
	gal./acre	No./acre	%	%	%	1-10	%
Nitamin	0	29,200	0	1.5	0	0	19.2
Nitamin	0.5	29,400	0	1.5	0	1.8	20.4
Nitamin	1.0	28,300	0	1.0	0	1.0	19.8
Nitamin	2.0	30,200	0	1.5	0	0.5	19.5
Nitamin	4.0	29,700	2	1.0	0	0.8	19.6
Headline at 6 oz/acre	0	28,500	0	1.0	0	1.8	20.8
Nitamin + Headline at 6 oz/acre	0.5	30,000	0	1.0	0	2.3	19.9
Nitamin + Headline at 6 oz/acre	1.0	29,300	0	1.0	0	2.0	21.1
Nitamin + Headline at 6 oz/acre	2.0	29,700	2	1.0	0	2.3	21.1
Nitamin + Headline at 6 oz/acre	4.0	28,300	7	1.0	0	2.5	21.3
Headline at 3 oz/acre + Nitamin	1.0	28,200	0	1.0	0	0.8	21.6
LSD ($P \leq 0.05$)		NS	1	NS	NS	1.4	1.6

[a]Abbreviations: CR, common rust (*Puccinia sorghi*); GLS, grey leaf spot (*Cercospora zeae-maydis*); LSD, least significant difference; and NS, non-significant.

[b]All Headline treatments were applied with nonionic surfactant at 0.25% v/v.

Table 3. Solution pH in the order of mixing, plant population, injury 14 days after treatment (DAT), incidence of disease (grey leaf spot 28 and 42 DAT, and common rust 42 DAT), SPAD 49 DAT, greenness (1=brown to 10=green) prior to harvest, and grain moisture as affected by Nitamin (30-0-0) alone and with Headline in 2009.

Treatment[a]	Rate	Spray solution		Population	Injury	GLS		CR	Spad	Greenness	Moisture
						28 DAT	42 DAT	42 DAT			
	gal./acre	pH	pH	No./acre	%	%	%	%	unit	1-10	%
Nitamin	0	7.5	7.5	26,800	0	1	7	3	31.7	0.3	26
Nitamin	0.5	8.6	8.6	26,400	0	2	8	2	35.5	1.0	26
Nitamin	1.0	8.8	8.8	27,700	0	1	6	2	36.2	0.5	27
Nitamin	2.0	8.9	8.9	27,500	1	1	7	2	35.4	0.5	26
Nitamin	4.0	9.2	9.2	29,200	4	2	9	3	38.9	0.5	27
Headline at 6 oz/acre	0	7.1	7.1	28,400	0	1	6	2	34.6	1.3	27
Nitamin	0.5	8.6		28,800	0	1	5	2	37.2	1.3	27
+ Headline at 6 oz/acre			7.9								
Nitamin	1.0	8.8		28,100	0	1	6	2	36.2	1.8	26
+ Headline at 6 oz/acre			8.2								
Nitamin	2.0	8.9		29,200	2	1	8	3	35.6	1.3	27
+ Headline at 6 oz/acre			8.5								
Nitamin	4.0	9.2		29,600	6	1	8	2	40.0	1.8	26
+ Headline at 6 oz/acre			9.0								
Nitamin	1.0	8.8		26,700	0	1	6	2	39.5	0.8	26
+ Headline at 3 oz/acre			8.4								
Headline at 3 oz/acre		7.6		29,000	0	1	5	3	31.7	0.8	26
+ Nitamin	1.0		8.1								
Headline at 6 oz/acre		7.6		27,500	0	1	6	2	35.1	1.3	26
+ Nitamin	1.0		8.2								
LSD ($P \leq 0.05$)		0.1	0.2	NS	1	NS	NS	NS	5.0	0.9	NS

[a]Abbreviations: CR, common rust (*Puccinia sorghi*); GLS, grey leaf spot (*Cercospora zeae-maydis*); LSD, least significant difference; and NS, non-significant.
[b]All Headline treatments were applied with nonionic surfactant at 0.25% v/v.

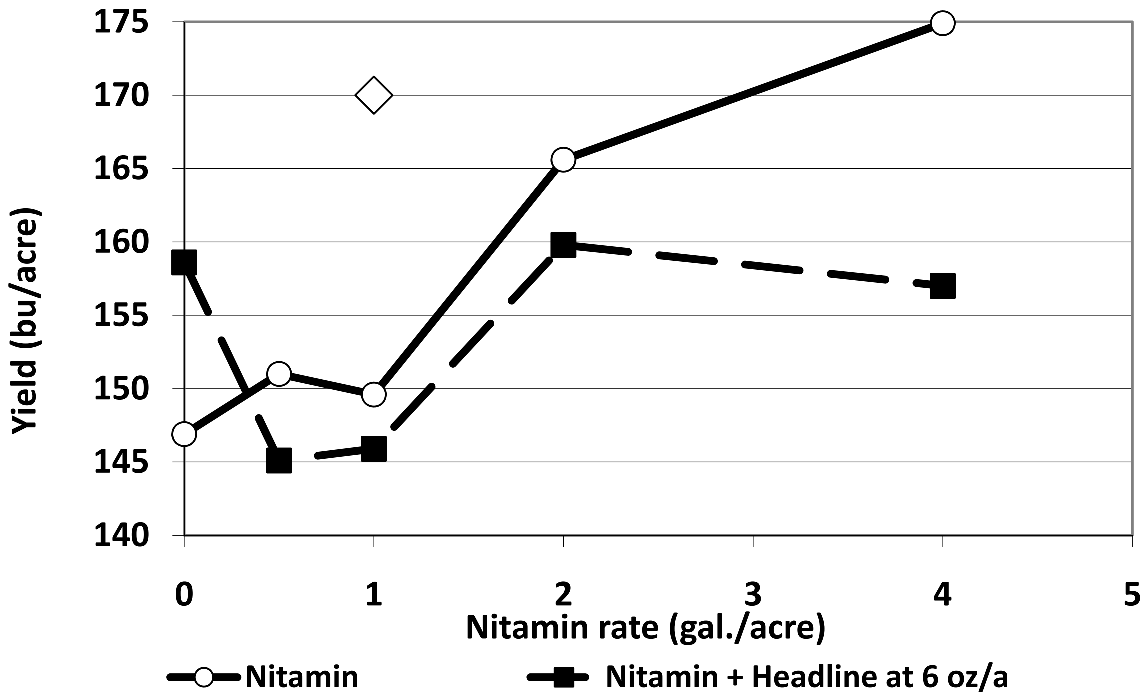

Figure 1. Grain yield response to Nitamin rates with and without Headline at 6 oz/acre or 3 oz/acre plus nonionic surfactant at 0.25% v/v in 2008. LSD ($P \leq 0.05$) was 18. Mixing order is the sequence listed in the legend.

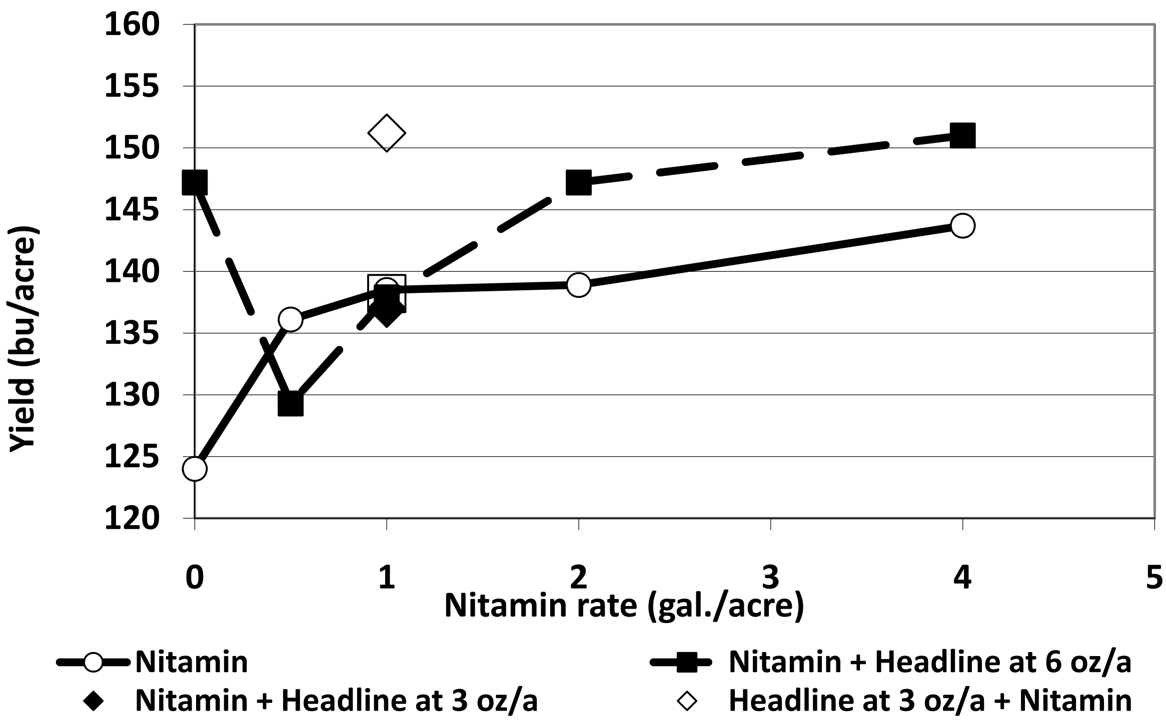

Figure 2. Grain yield response to Nitamin rates with and without Headline at 6 oz/acre or 3 oz/acre plus nonionic surfactant at 0.25% v/v in 2009. LSD ($P \leq 0.05$) was 14. Mixing order is the sequence listed in the legend.