The Effect of Headline® Foliar Fungicide on Corn Silage Yield & Quality

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Interest in applying foliar fungicide to field corn has grown in recent years. One estimate suggests 10-15% (>400,000 ac) of all field corn in Wisconsin (10% or >9 million ac nationwide) was sprayed with a foliar corn fungicide in 2007. Current recommendations indicate foliar fungicides can effectively reduce severity of corn leaf diseases, but are rarely economical[1]. Meanwhile, visual observations cited by growers and agronomy professionals (less dead or diseased plant tissue, better color and stalk strength) has added to the growing interest.

In northeast Wisconsin, where concentration of dairy cows is high and ¼-½ or more of all field corn is harvested as silage, some producers and crop consultants believe a more consistent yield response is likely when foliar fungicide is applied to corn fields harvested for silage. Some believe silage quality is improved from healthier plant tissue, thus less mold/mycotoxins are brought into storage. "Limited Wisconsin studies to date have shown a tendency toward improved silage yields and milk/ac values with a foliar fungicide application. However, it is premature to make any firm recommendation at this time until more hybrids and site-years are tested."[2]

RESEARCH DESIGN, METHODS AND MATERIALS

In Summer 2007, a field research plot was established on a farm in Waupaca County, WI, to evaluate effects of foliar fungicide on corn silage yield and forage quality, including molds and mycotoxins. The trial was conducted using field scale equipment and two treatments (with and without foliar fungicide).

Field history shows six to seven years of consecutive corn with the previous three years harvested as silage (15% residue at planting). A 115-day relative maturity silage hybrid (Pioneer 33A88 - Herculex I corn borer, Liberty Link and Round-Up Ready Corn 2) with a low rust disease rating was planted on May 5 at 34,000 seeds/ac. Fertilization included pop-up seed furrow starter fertilizer (7-21-7, with zinc and sulfur) with a 26% nitrogen solution (14-15 gallons, or 40-45 units of N) sprayed two weeks after planting. Weed control included Round-Up (1 qt/ac) and Dicamba (3 oz/ac) applied in late May with 32% nitrogen solution (2 qts). Anhydrous ammonia (120 units of N) was side-dress applied in early June.

On July 2, a foliar fungicide treatment was applied using a randomized complete block design with three replications. Treatments were an untreated check and 6 ounces of Headline with one pint non-ionic surfactant/100 gallons of water applied at 20 gallons/ac using a high clearance ground sprayer with flat fan fine mist nozzles. A corn leaf disease assessment was made in each replicated treatment the same day just prior to application. The percent estimated total "blighted" or diseased foliage above the ear zone was assessed in each replication. At the time of application, corn plant development was identified at stage V11-VT (tassels emerging).

On September 14th, a pre-harvest plot assessment was conducted.[3] Data obtained included foliar disease ratings, premature tassel/flag leaf death and stalk evaluation information. Twelve ears of corn were taken from each replicated treatment during the pre-harvest assessment (six from each end of the plot), then sealed in a zip-lock bag and immediately frozen before being sent to the North Dakota State University (NDSU) Veterinarian Diagnostic Lab for aflatoxin and fumonisin mycotoxin analyses using a variety of extraction methods, including mass spec and HPLC techniques.

All treatments were harvested on September 21 using a pull-type chopper with a kernel processor. A certified feed mill scale was used to weigh each replication (a total of three rows or 0.12 total ac were chopped from the center of each 24-row replication). No inoculants or preservatives were applied.[4]

While unloading silage from each replication at the blower, a sample was collected by taking random handfuls and filling a five gallon pail. A sub-sample was then collected, vacuum sealed and fermented for three weeks in a "food saver" bag followed by NIR forage quality analysis at the UW-Madison Marshfield Agricultural Research Station.

Two other sub-samples were taken from the sample pail, bagged and immediately frozen for shipping and mycotoxin analysis at NDSU Veterinary Diagnostic Lab. NDSU technicians then split and sent a portion of each sub-sample to Midwest Laboratories in Omaha, NE, for additional mold and yeast counts (all samples were received, verified and analyzed the same day using FDA/BAM or XVIII methodology with a minimum detection limit of 10 cfu/g).

RESULTS AND DISCUSSION

Pre-Treatment and Pre-Harvest Stand Assessment[5]. Minimal (<1%) corn leaf disease was found the day treatments were applied (July2). Diseases observed included: common rust, northern corn leaf spot, and anthracnose, respectively; but no visual or statistical differences were found between treated or untreated areas.

Prior to harvest (September 14), disease assessment again identified common rust, northern corn leaf spot and anthracnose as the predominant corn leaf diseases across all replications respectively. The assessment found areas treated with foliar fungicide had ~5% less "blighted" or diseased tissue (2.5% with and 7.5% without fungicide), although this difference was not statistically significant (Table 1).

In addition, there were fewer failed or rotten stalks between the treated (14%) and untreated (30%) areas, but the difference was not statistically significant. The results may suggest a trend toward improved stalk performance with a significant statistical difference at a lower confidence level ($0.20 > P > 0.10$). The number of corn plants showing signs of premature death (dead tassel or flag leaf) was statistically significant (Table 1.), with a high level of confidence ($P<0.10$) for fungicide treated (4%) vs. untreated areas (10%).

Results suggest Headline foliar fungicide can improve the health of corn plants when harvested as silage. Silage harvested from treated areas was 65.7% moisture, 1.5% drier than untreated areas (Table 2). Wet corn silage yield (23.7 tons/ac) for treated areas was 0.8 ton/ac more (+4%) than untreated areas. On a DM basis, the average yield was 8.2 tons DM/ac and 0.7 tons DM/ac more (+ 9%) for treated areas (Table 3). Although none of these differences were statistically significant, the analysis does suggest a trend ($0.20 > P > 0.10$) toward increased forage DM yield from corn treated with Headline foliar fungicide may be possible. Forage quality analysis (Table 4), including the UW milk/ton index (Table 5), showed no significant difference between treated (3,502 lbs milk/ton) or untreated (3,427 lbs milk/ton) areas.[6] However, results from the feed quality analysis (Table 4) suggest a possible trend ($0.20 > P > 0.10$) toward lower or improved neutral detergent fiber (NDF), or % of cell wall fiber, which is inversely related to feed intake, for treated (39.6% NDF) vs. untreated areas (40.6% NDF). This potential trend of lower NDF values and the possible trend toward higher silage DM yield may also help explain a similar trend ($0.20 > P > 0.10$) in the milk/ac index (Table 5) between treated (28,317 lbs milk/ac) and untreated areas (25,814 lbs milk/ac).

Results suggest Headline foliar fungicide may improve overall silage output as measured by UW milk/ac, possibly through increased DM yield and/or lower NDF values (Table 4).

Molds, Yeasts and Mycotoxins[5]. Laboratory analysis found no difference between samples from areas treated with fungicide (Table 6). In fact, vomitoxin was the only mycotoxin found above minimum detection level, but at a very low level (1.2 ppm) for both treated/untreated areas.

Table 1. *Pre-Harvest Stand Assessment*

Pre-Harvest - Sept. 14	Control	Treatment	Change
Diseased Foliage/Plant	7.5%	2.5%	-5%
Premature Plant Death	10.0%	4.0%	-6%*
Lodged or Rotten Stalks	30.0%	14.0%	-16%

**Statistical significant difference with 90% confidence level (P<0.10)*

Table 2. *Harvested Whole Plant Corn Silage Moisture & DM*

Moisture - Sept. 21	Control	Treatment	Change
% Whole Plant Moisture	67.2%	65.7%	-1.5%
% Dry Matter (DM)	32.8%	34.3%	+1.5%

Table 3. *Harvested Whole Plant Corn Silage Yield*

Yield - Sept. 21	Control	Treatment	Change
Wet Yield (tons/ac)	22.9	23.7	+0.8 tons/ac
DM Yield (tons/ac)	7.5	8.2	+0.7 tons/ac

Table 4. *Harvested Whole Plant Corn Silage Forage Quality*

Quality	Control	Treatment	Change
CP (%DM)	9.0%	9.1%	+0.1%
NDF (%DM)	40.6%	39.6%	-1.0%
NDFd (%NDF)	58.7%	60.5%	+1.8%
Starch (%DM)	32.3%	34.2%	+1.9%

Table 5. *Harvested Whole Plant Corn Silage Quality & Yield Index*

Quality/Yield Index	Control	Treatment	Change
Lbs Milk/ton	3,427	3,502	+75
Lbs Milk/ac	25,814	28,317	+2,503

Table 6. *Harvested Whole Plant Corn Silage Mycotoxin Analysis*

Mycotoxin	Control	Treatment	Change
DON (vomitoxin)	1.2 ppm	1.2 ppm	0%
T-2	<0.50 ppm*	<0.50 ppm*	0%
Zearalenone	<0.50 ppm*	<0.50 ppm*	0%
Aflatoxin	<0.02 ppm*	<0.02 ppm*	0%
Fumonisin	<2.00 ppm*	<2.00 ppm*	0%

** Denotes minimum detection level. DON (vomitoxin), T-2, and Zearalenone results based on two frozen fresh samples collected from each replication during harvest. Aflatoxin & Fumonisin results based on 12 cobs collected from 2 locations in each replication 1 week prior to harvest. All samples were analyzed at NDSU Veterinary Diagnostic Lab using gas chromatography, mass spectometer and HPCL techniques.*

SUMMARY AND IMPLICATIONS

Assuming a combined foliar fungicide and ground application cost of $25/ac and the harvested value of corn silage at $30/ton as fed ($87/ton DM), silage yield alone would need to consistently increase by nearly 0.3 tons DM/ac to break-even with the added investment.

Results suggest Headline foliar fungicide applied to field corn may be able to improve corn silage output when measured by milk/ac, possibly by increasing yield (more lbs DM/ac), improving forage quality (lower NDF) or a combination of both. Further research is needed across multiple locations and years to verify both agronomic and economic effects, including if and when any benefit should be expected from lower mold or mycotoxin levels.

Finally, additional field studies should explore the effect of high-end label application rates (9 oz vs. 6 oz) and/or aerial application during later stages of plant development when disease pressure is greatest and use of ground sprayers is prohibited.

1 UW-Ext. Pub. A3646 Pest Management in WI Field Crops, 2007 (p. 74).

2 Agronomic Considerations for Molds and Mycotoxins in Corn Silage and High Moisture Corn. Mike Rankin, Fond du Lac County UW-Ext. Crops and Soils Agent and Craig Grau, Ext. Plant Pathologist, UW-Madison.

3 It should be noted exceptional growing conditions occurred between planting in early May and fungicide application in early July, followed by extremely dry and warm weather into July and Aug., then back to a more normal rainfall and temperature pattern before a hard frost occurred on Sept. 15.

4 Yield and quality data from the 3rd replicated fungicide treated area was abandoned since the load was inadvertently mixed with another hybrid.

5 Statistical analysis by Paul Esker, Asst. Prof. and Ext. Field Crop Plant pathologist, UW-Madison using SAS v9.1.3 and a MIXED MODEL procedure.

6 Milk/ton and milk/ac values calculated using MILK2006 Corn Silage spreadsheet.

2007 Corn Silage Foliar Fungicide Research Project Results [1,2]

Midwest Forage Association/Waupaca County Forage Council/University of Wisconsin Extension

UT - Untreated; T - Treated

	Rep #1		Rep #2		Rep #3		Mean	Mean
Pre-Application Disease Rating	UT	T	UT	T	UT	T	UT	T
AVG % diseased foliage/plant [3,4]	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Pre-Harvest Disease Rating	UT	T	UT	T	UT	T	UT	T
AVG % diseased foliage/plant [5]	5%	1-5%	5-25%	1-5%	1-5%	1-5%	7.5%	2.5%
# premature deaths per 30 plants [6]	4.0	3.0	2.0	0.0	3.0	1.0	3.0	**1.3**[a]
# lodged or rotten stalks/30 plants [7]	12.0	6.0	3.0	3.0	12.0	4.0	9.0	4.3
Aflatoxin #1 (ppm) [8]	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Aflatoxin #2 (ppm) [8]	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fumonisin #1 (ppm) [8]	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Fumonisin #2 (ppm) [8]	<2.00	<2.00	<2.00	**2.00**	<2.00	<2.00	<2.00	<2.00
Harvest Data	UT	T	UT	T	UT	T	UT	T
Wet Yield (tons/ac) [9]	23.19	23.52	21.92	23.77	23.44	na	22.9	23.7
DM Yield (tons DM/ac)	7.77	8.61	7.17	7.63	7.57	na	7.5	**8.2**[b]
DM (%) [10]	33.5%	36.6%	32.7%	32.1%	32.3%	na	32.8%	34.3%
Silage Moisture (%)	66.5%	63.4%	67.3%	67.9%	67.7%	na	67.2%	65.7%
CP (% DM) [10]	8.6	8.4	9.4	9.7	9.1	na	9.0	9.1
NDF (% DM) [10]	40.2	39.4	39.8	38.5	41.9	na	40.6	**39.6**[b]
NDFd (% NDF) [10]	58.0	61.0	58.0	60.0	60.0	na	58.7	60.5
Starch (% DM) [10]	32.3	35.2	33.1	33.1	31.6	na	32.3	34.2
Ash (% DM) [10]	3.6	3.5	3.6	3.9	3.8	na	3.7	3.7
Fat (% DM) [10]	3.0	3.0	3.1	2.9	2.7	na	2.9	2.9
Milk/Ton Index [10]	3439	3504	3458	3499	3384	na	3427	3502
Milk/Ac Index [10]	26823	30134	24899	26594	25719	na	25814	28317[b]
Fermented Silage Mold Analysis	UT	T	UT	T	UT	T	UT[a]	T[a]
Total mold count #1 (cfu/g) [11]	24,000	160,000	140,000	70,000	110,000	na	83176	87096
Total mold count #2 (cfu/g) [11]	30,000	120,000	110,000	38,000	220,000	na		
Yeast #1 (cfu/g) [12]	6,000	130,000	40,000	40,000	50,000	na	32359	87096
Yeast #2 (cfu/g) [12]	40,000	50,000	20,000	130,000	50,000	na		
Fermented Silage Mycotoxin Analysis	UT	T	UT	T	UT	T	UT	T
Vomitoxin #1 (ppm) [13]	1.0	1.3	1.5	1.0	0.8	na	1.17	1.2
Vomitoxin #2 (ppm) [13]	1.5	1.5	1.3	1.0	0.8	na		

[a] *statisticallly significant (P<0.10); determined by dead tassel or flag leaf.*

[b] *possible trend??? (0.20>P>0.10)*

Table Footnotes

1 Brian Long, grower, Weyauwega, WI; Mike Kiddy, Kiddy Crop Consulting, New London, WI and Greg Blonde, Waupaca Co. UW-Ext Ag Agent and Waupaca County Forage Council (WFCF) officer/local council contact. Financial support provided by Midwest Forage Association (MFA), WCFC (an MFA Local Affiliate) and UW-Ext-Madison Plant pathologists Paul Esker, Craig Grau and Bryan Jensen. Headline fungicide provided by Mike Tuss, BASF Agronomy Spec.

2 Field history was consecutive corn (previous 3 years harvested as silage with 15% residue at planting). Pioneer 33A88 (115-day CRM, double-stack Herculux I corn bore and Liberty Link herbicide resistant; 3 or low disease resistance rating for rust). Planted May 5 at 34,000 seeds/ac using pop-up seed furrow starter fertilizer (7-21-7 + zinc and sulfur). 40-45 units of N (14-15 gallons of 26% N solution) sprayed 2 weeks after planting. Round-Up (1 qt/a) and Dicamba (3 oz/ac) were applied late May along with 32% N solution (2 qts). Anhydrous ammonia (120 units of N) side-dressed in early June.

3 Jul. 2 the field plot was marked (excluding headland rows) to accommodate sprayed/unsprayed treatments. Treatment order was randomly assigned and replicated 3 times. Final layout included 24 untreated rows followed by 24 treated rows with the same pattern repeated 2 more times for a total of 144 consecutive rows in the plot.

4 Immediately following plot layout on Jul. 2, preliminary disease ratings were collected with little sign of foliar disease detected except a few very early signs of rust and northern corn leaf blight uniformly scattered throughout. That afternoon, Headline was applied (6-9 oz) using a high clearance ground sprayer (flat fan fine mist nozzles) with 1 pint of non-ionic surfactant/100 gallons of water at 20 gallons/ac.

5 Pre-harvest plot assessment data including foliar disease ratings, premature tassel death and stalk evaluation were collected with Paul Esker on Sept. 14. Rust and northern corn leaf blight were most prevalent (respectively) with smut scattered lightly throughout the plot. Untreated area in the second replication showed comparatively more diseased leaf area, but less stalk damage.

6 Premature tassel death (identified by dead flag leaf) appeared less variable and more random throughout the plot.

7 More failed stalks identified as smaller, delayed germinators. More "borderline" failed stalks in the untreated areas of reps #1 and #3.

8 During pre-harvest assessment (Sept. 14), a total of 12 ears of corn were collected from each replicated treatment (6 from north and 6 from south half of the plot), then sealed in a zip-lock bag and frozen before being sent to the NDSU Veterinarian Diagnostic Lab for aflotoxin and fumonisin mycotoxin analysis (a variety of extraction methods were used, plus mass spec and HPLC; the practical quantitation limit or PQL for Aflatoxin is 0.02 ppm and 2.0 ppm for Fumonisin).

9 Treatments harvested Sept. 21 (yield/quality analysis from the treated area of replication #3 were abandoned due to multiple hybrids inadvertently chopped into same wagon). A scale was used to weigh each load (3 rows near the center of each 24 row replicated treatment to avoid border influence between treated and untreated areas).

10 After each replicated treatment was weighed, silage from each load was collected at the blower by taking random handfuls and filling a five gallon pail. A sub-sample was then collected, vacuum sealed and fermented for 3 weeks in "food saver" bags followed by NIR analysis at the UW-Madison Marshfield Ag Research Station (2 other sub-samples were taken from the pail, bagged and immediately frozen for shipping and analysis at the NDSU diagnostic lab).

11 Samples were split at the NDSU lab with sub-samples sent to Midwest Laboratories in Omaha, NE, for additional mold and mycotoxin analysis. Samples were received, analyzed and verified at the lab on the same day using FDA/BAM methodology with a minimum detection limit of 10 cfu/g. Mold types identified included: *Apergillus sp.*(other); *Penicillium sp.*; *acmonium sp.,* and *Rhizopus sp.* (specific levels of each mold for each sample available on request).

12 Yeast counts were done on each sub-sample by Midwest Laboratories using FDA XVIII methodology with a minimum detection limit of 10 cfu/g.

13 Using a variety of extraction techniques, plus mass spect and HPLC, the NDSU lab analysis on each of the 2 sub-samples from each replicated treatment did not find anything above the minimum detection level of 0.05 ppm for the following mycotoxins: T-2 Tetraol, Fusarenone-X, 3-Acetyl DON, 15-Acetyl DON, DAS, T-2 Triol, T-2 Toxin, Iso T-2 toxin, Scirpentriol, Nivalenol, 15-Acet-Scirp, Neosolaniol, HT-2 Toxin, Acetyl T-2, Zearalenol, and Zearalenone.