Cornell Cooperative Extension

South Central NY Dairy and Field Crops Program

Final Report for:

A Comparison of the Performance of Pre & Post Tassel Fungicide Applications in Corn for the Control of Northern Corn Leaf Blight

(OSP 82071 NYFVI)

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Abstract

Northern Corn Leaf Blight (NCLB) is one of the most serious diseases of corn. It has become endemic in NYS, affecting all corn growers. Although we cannot predict when first infection will occur, it has occurred regularly for over ten years consecutively. This field scale study sought to measure and compare effects on yields and quality from fungicide treatment at an early and late timing on five cooperating farms in Northern, Central and Eastern New York. Applications were made at two timings: early vegetative and reproductive. Treatments included: 1) an untreated control, two early vegetative fungicide treatments with 2) Priaxor® and 3) Affiance®, and two post tassel treatments of 4) Affiance® and 5) Headline Amp®. This year was an anomaly because occurrence was absent to arriving fairly late and then only with light infection. NCLB disease incidence was very low, below 1% in the majority of the plots. Although disease pressure from common rust was abundant as well as other abiotic stress factors, there were no statistically significant effects on yield or forage quality components from the fungicide treatments compared to the untreated check plots.

Introduction

Northern corn leaf blight (NCLB) is caused by the fungus *Exserohilum turcicum*, which attacks the leaves of the corn plant. This disease is a serious concern for farmers in NYS because it can dramatically reduce corn yields and possibly impair silage quality. Evidence from the Midwest suggests that NCLB can reduce yields as much as 50% when plants are infected at an early stage of development. The Ohio State University Extension reports (Salgado et al. 2016) that "severe damage caused by NCLB also predisposes plants to stalk rot and lodging, which may further reduce yield and grain quality." NCLB is one of the most common foliar diseases of corn in the Midwest, where farmers have experienced an increasing prevalence and severity of the disease since the early 2000s. Farmers in NYS have seen a similar growth in both the occurrence and impact of NCLB.

NCLB infection and development respond to several factors: the presence of inoculum, climatic conditions conducive to infection (moderate temperature and long wetting period), and the presence of a susceptible host. Disease inoculum can be present on crop residue in continuous corn, or can arrive during the growing season carried on air currents, particularly on storm fronts. According to Wise (2011), "NCLB infection occurs when conidia are exposed to 6-18 hours of leaf wetness and moderate (66-80°F) temperatures. Susceptible hybrids and high nitrogen soils also increase disease risk."

While there is no predictable correlation between ***disease severity*** and yield loss, ***the timing of infection*** has major consequences for yield and quality outcomes (Wise 2011). According to The Ohio State University Extension (Salgado et al. 2016), "during wet weather yield losses may be as high as 30-50% if the disease becomes established before tasseling. However, if leaf damage is only moderate or is delayed until 6 weeks after silking, yield losses are minimal. Similarly, Purdue University (Wise 2011) reports that "if lesions have reached the ear leaf during the two weeks before and after tasseling, yield loss could occur. Hybrid corn yield could be reduced as much as 30 percent if lesions are present prior to or at tasseling." The timing of NCLB infection is highly variable and difficult to predict from year to year, which complicates the management of this disease.

Application of fungicides is an important management tool to control NCLB in corn. There are nearly 20 fungicides from two chemical families that are labeled for control of NCLB. Fungicides labeled for NCLB are mainly protectants. Some may have limited systemic activity. They work best when applied at the first sign of infection to adequately control the disease.

Late season fungicide applications in silage have been identified as a research priority by the New York Corn and Soybean Growers Association (NYCSGA), yet farmers face several barriers to adopting post tassel fungicide applications. Many farms do not have equipment that accommodates a full sized crop, so they must rely on custom applicators. Farmers may not be convinced that a yield benefit will outweigh the cost of treatment, especially when taking crop damage by the application equipment into account. Aerial applications that avoid crop damage have the downside of alerting nearby neighbors to pesticide use, potentially damaging public relations.

The fungicides Affiance®, Priaxor®, and Headline Amp® were chosen for this study because they are commonly used and industry representatives were interested in supporting research to document their performance. The fungicides each have two ingredients providing mixed modes of action.

Affiance® and Priaxor® are purported to have 30 days of systemic activity and are labeled for an early application timing when corn is still vegetative, which can be combined with post emergence weed control.

Headline Amp® is rated "very good" for control and is the fungicide used by many custom applicators. In addition to pathogen control, these fungicides are promoted for offering "plant health" benefits even in the absence of disease pressure. Trial results have been mixed regarding the exhibition of plant health benefits in the absence of disease (Mallowa 2015) . The majority of efficacy testing to date has taken place in the Midwest. Due to a lack of data from trials in the Northeast, advisors in NYS rely on information from Midwestern trials to develop local recommendations.

This study was conducted on five farms across three regions of NYS to measure and compare impacts of fungicide treatments for control of NCLB on corn silage yields, plant health and forage quality. Fungicide treatments were applied at two different stages of crop development, early vegetative (V4-V6) and post tassel, to assess whether early applications could provide acceptable crop protection compared to later applications at or after tassel. Forage samples were collected to assess potential impacts of each treatment on forage quality. Yield results and silage price were used to compare cost of fungicide application with value of yield gained in a cost-benefit analysis. In a season absent of heavy disease pressure, there is added value from this project in evaluating possible secondary impacts on plant performance and economic returns associated with fungicide application.

Material and Methods

Experimental Design

This trial was established at field scale on five farms located in three regions of New York State: North Country, South Central NY, and Eastern NY. We purposely included farmers who grow BMR varieties and corn fields with a previous corn crop since NCLB overwinters on corn tissue providing a local source of inoculum. Three of our four cooperating farms grew BMR hybrids and were selected because BMR hybrids are known to be more susceptible to NCLB infection. In some years, NCLB has infected the BMR varieties earlier than non-BMR varieties which then lead to more severe leaf tissue loss.

Our cooperating farmers prepared and planted the fields using their own standard practices for hybrid selection, planting density, tillage, fertility and weed control practices. Table 1 outlines basic plot information. At each farm, three replicates of five treatments were established using a randomized complete block design (RCBD). The plot plan with treatments is shown in Figure 1.

Figure 1. Graphic of Plot Plan for All Sites

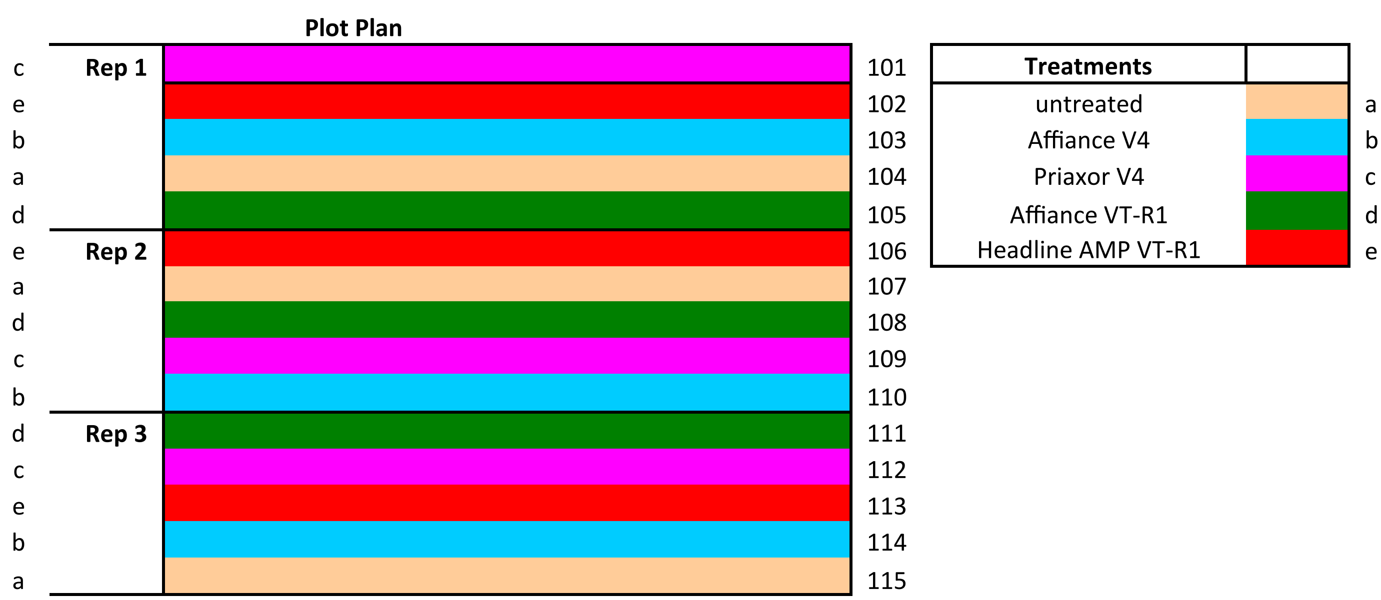


Table 1. Background Information for Site

Site	Location	Field Size (Ac)	County	Hybrid	Maturity	BMR	Year of Corn	Planting Date 2017	Planting Rate	Plot Width (ft)
ER	E. Homer	39	Cortland	Pioneer P1449	114 CRM	Y	continuous	4/29	35,011	90
CV	Tully	48	Onondaga	Pioneer 0921 AMXT	109 CRM	N	2nd year	5/5	35,000	60
WR	Lansing	85	Tompkins	Mycogen 12B75	112 RM	Y	2nd year	5/17	36,000	90
WH	Salem	32	Washington	Mycogen P1180XR	111 RM	Y	3rd year	4/26	32,000	60

Corn was planted in the months of April and May. Plots were laid out in late May after the corn had germinated. Plot sizes were dictated by field size and spray equipment. Plots were 60 ft. wide (24 rows of corn) or 90ft. wide (36 rows of corn). A summary of planting, treatment and harvest dates are shown in Table 2.

Table 2. Planting, Treatment & Harvest Dates 2017

Farm Cooperator	Planting Date	V4-6 Applications	VT Application	Harvest
Site 1	5/17	6/18 (V5)	8/17	9/30
Site 2	4/29	6/16 (V4)	8/16	10/4
Site3	5/5	6/26 (V6)	8/17	9/29
Site 4	4/26	6/22	7/31	9/18

Fungicide Treatments and Application Timing

Two fungicides treatments, Priaxor® (BASF) at 5 oz/ac and Affiance® (Gowan) at 10oz/ac, were applied during an early vegetative stage between V4-V6. This application timing was chosen to evaluate whether an early treatment would provide adequate season long protection, since many farms do not have access to a high clearance sprayer, which is required for a post tassel treatment. The original intention was to combine these fungicide sprays with the post emergence herbicide glyphosate. However, high weed pressure due to wet conditions created undesirable competition with the corn. Farmers at most of our sites chose not to delay the herbicide until the V5 stage, except at the WR location where the herbicide and the fungicide treatments were applied in separate applications on the same day.

Two other fungicide treatments were applied post tassel with high clearance sprayers: Affiance® (Gowan) at 10oz/ac and Headline Amp® (BASF) at 12 oz/ac. This application timing was chosen to avoid any damage that has been seen when spraying near to tasseling, particularly when NIS or crop oil spray additives are used (Nielsen et al, 2008). A strip that received no fungicide treatment was included in each replication as the control.

Due to wet conditions at the North Country site during the 2017 growing season, the farm was unable to complete applications of the post tassel fungicide treatments. Thus, data from the North Country site was incomplete, and this site is excluded from the statistical analysis.

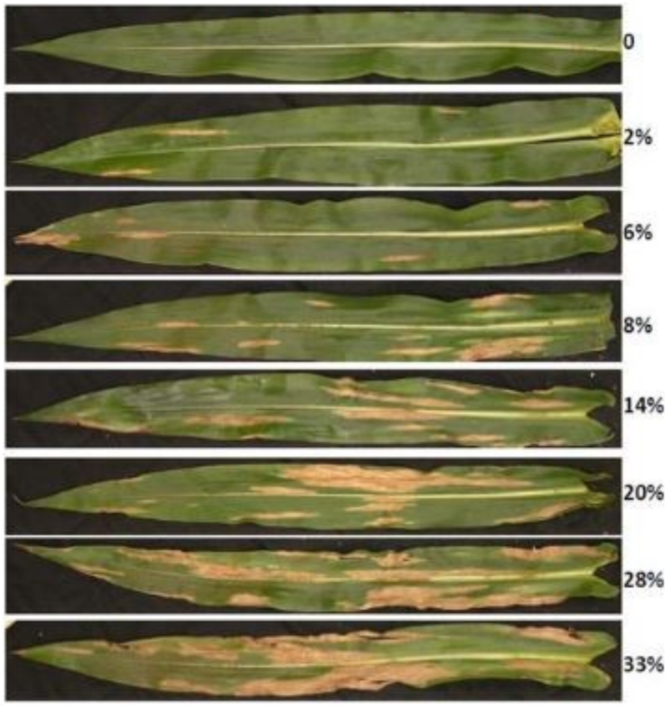
Data Collection and Analysis

Disease presence, particularly NCLB, was monitored throughout the season. A final assessment of NCLB infection was done in the week prior to harvest. Five contiguous plants were assessed at four sites within each treatment. The NCLB Severity Rating Scale (%) developed by Price et al. 2015, LSU was used for rating disease infection levels (Figure 2). The rating scale provides a standard reference of infected leaf area for comparison when assessing disease incidence in the field.

Plant population density (plants per acre) was measured in each treatment. After plot establishment, plants were counted at 6 sites in each treatment in a distance equivalent to 1/1000 of an acre (30 inch rows =17 ft 5 in).

Crop yields were collected with yield monitors. Equipment on the choppers continuously recorded incoming crop tonnage and moisture. This yield data was integrated with GPS coordinates.

Figure 2 . NCLB Severity Rating Scale (%), Price et al 2015, LSU



To ensure every raw data point was imported, the raw yield monitor dataset was imported to SMS advanced software without applying any filter settings. Once in SMS, the dataset was exported out of the SMS software in AgLeader advanced text file format. Exported text files were imported into Yield Editor software and cleaned using the procedure/protocol described in Kharel et al. (2018). Briefly, the 'Automated Yield Cleaning Expert (AYCE)' tool available in Yield Editor software was used at the beginning of data cleaning. Delay values (flow delay, moisture delay, start pass delay and endpass delay) were then adjusted based on spatial data agreement as described in the protocol/manual. The idea was to match similar flow, moisture and yield values to the nearby data points when two opposite harvest passes come together. After agreeing with the filter values, cleaning was run in the raw dataset which were exported in 'csv' format from the Yield Editor. The cleaned exported dataset was used for further data analysis. Each cleaned dataset was imported to ArcMap (ArcGIS referenced) and converted to a shapefile. Using the four corner points of each plot, plot polygons were created. Two to three harvest passes that were at the boundary of two adjacent plots were discarded to remove the boundary effect and central passes were selected. Average yield values for each plot were calculated using selected central harvest passes.

Forage samples were collected from each treatment to measure any impacts to crop quality from the fungicide treatments. We lost one forage sample (treatment 104) at site three, and were only able to collect forage samples from seven treatments at site four. As a result, statistical analysis of treatment effects on forage quality uses only the data collected from sites 1-3.

Forage analysis was done by the Dairy One Laboratory in Ithaca, NY. The NIR Pro package (327) with an added uNDF analysis was run on the samples. The 327 package analyzes crop dry matter (DM), crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF), starch, NDF digestibility at 30 hours and indigestible NDF at 240 hours. A total of 32 forage samples from sites one, two, and three were also analyzed for mycotoxin levels by AllTech® using an ELISA rapid test to measure deoxynivalenol (DON) levels in parts per billion (ppb).

Crop yield and forage quality data were analyzed using JMP statistical software. An analysis of variance (ANOVA) model was run using randomized complete block design (RCBD), where treatment effect was estimated and reported using a p-value of 0.05 for significance.

Results

Plant Population Density

Mean plant population density for all plot treatments was 31,276 plants per acre. Table 3 presents mean plant population density by site and by treatment. Plant density did differ significantly by farm but not for treatments. Population ($F = 1.59$, $p = 0.2133$), Site: ($F = 25.25$, $p < .001$), and Treatment ($F = 1.15$, $p = 0.3446$).

Site 1 – June 29

Environmental Stress

Plant Health & Climate Stress

The weather in 2017 created season long challenging conditions for crop planting and development. Excess moisture and generally cool conditions prevailed until late summer/early fall (mid-September to mid-October). The fields in this trial experienced stress from excess moisture and waterlogged conditions in pockets in the field from May through July. The severity among the fields as well as locations within fields varied. The excessive soil moisture also contributed to spotty nitrogen deficient plants in the fields at the time of harvest, even though all of the SCNY fields were side-dressed. By the end of the season, the development of common rust was present at all locations. The field at Site 3 was the most uniform in terms of soil conditions and plant growth, but did have a high incidence of common rust.

Syracuse received 1.22 inches of rain, 69% of normal (1.78”).

Table 3. Plant Populations by Site and Treat-

Farm Cooperator	Untreated	Affiance V4-6	Priaxor V4-6	Affiance VT	Headline VT
	plants/ac				
Site 1	34,667	34,667	35,333	36,000	34,333
Site 2	31,667	30,667	31,667	30,000	31,667
Site3	30,000	30,667	29,333	27,333	31,000
Site 4	29,222	29,396	29,200	29,555	29,148

Table 4. Disease Rating by Site and Treatment

Farm Cooperator	Untreated	Affiance V4-6	Priaxor V4-6	Affiance VT	Headline VT
	% Incidence				
Site 1	1	1	1	<1	1
Site 2	0	<1	0	<1	<1
Site3	0	0	0	0	<1
Site 4	<1	0	<1	0	0

The field at Site 1 experienced the most climate stress of the three South Central NY sites. Although not continuous, there were periods of waterlogged sections of the fields from May through July. As a result, extreme purpling of plants was exhibited up to 6 leaves, which was about the timing of the early fungicide applications. The Site 2 field was 39 acres and generally had good drainage although there were areas with poorer drainage particularly in the first repetition, treatments 101-105.

Despite relatively high rates of precipitation, which lead to several distinct periods of ponding and waterlogged conditions in fields, development of NCLB was very light across the study region. The disease ratings are summarized by plot and treatment in Table 4. The highest rating of corn leaf tissue damage from NCLB in any sample from the four sites was 6%. Most ratings fell within 0-1%. The incidence of NCLB was low at all four farms across all treatments, including the untreated controls and no statistical evaluation was done.

Appendix I provides a detailed review of the weather recorded during the 2017 growing season at Syracuse, NY by the National Weather Service. Syracuse is the nearest National Weather Station and provides an accurate picture of the weather patterns at sites 1-3.

Crop Yield

Across all study plots, mean crop yield was 24.1 tons per acre at 35% dry matter. Table 5 lists mean crop yields by site and treatment. Analysis of variance (ANOVA) produced no evidence of any significant difference in mean crop yields according to treatment ($F = 0.91$, $p = 0.47$). However, mean crop yields did vary significantly by site ($F = 24.9$, $p < 0.0001$). Sites 2 and 3 had higher average crop yields. The variation in crop yields across the different sites cannot be explained by variation in planting densities, as ANOVA shows no evidence of any relationship between plant population density and crop yield ($F = .8173$, $p = 0.3704$).


Site 2 – Late Summer: Condition of Crop


Site 1-Stand variability resulting from


Site 2– Leaf Senescence: Biotic and Abiotic Stresses

Table 5. Yield by Site and Treatment

Farm Cooperator	Untreated	Affiance V4-6	Priaxor V4-6	Affiance VT	Headline VT	Average Yield (Site)
	Yield T/Ac @ 35% DM					
Site 1	22.45	21.78	21.24	21.28	23.89	22.13
Site 2	27.04	27.41	28.01	26.94	24.39	26.76
Site 3	26.57	26.52	25.73	25.53	25.58	25.99
Site 4	21.1	22.4	21.9	21.4	21.3	21.63

Figure 2. Average corn silage yields by site and treatments with standard error bars.

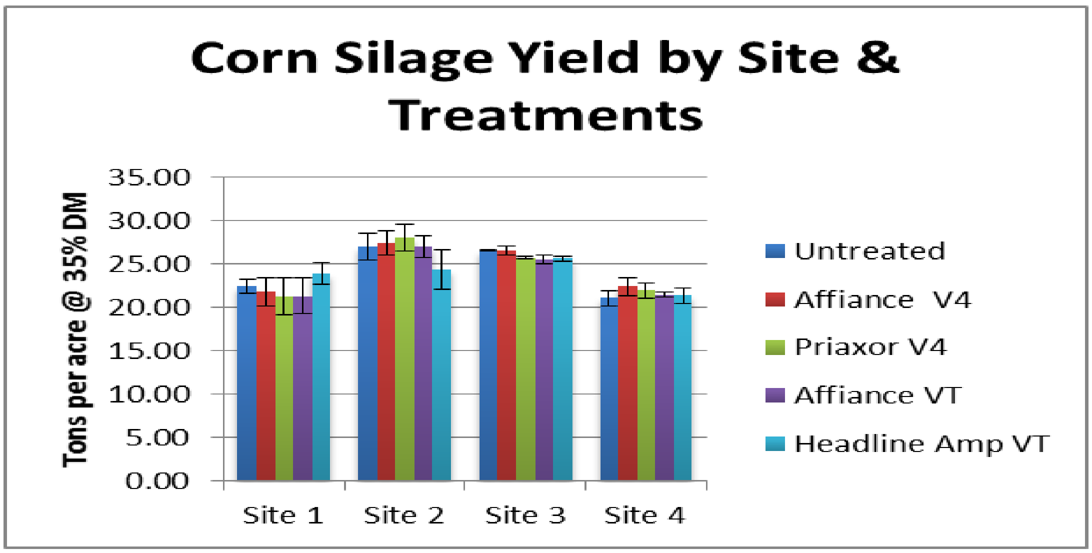
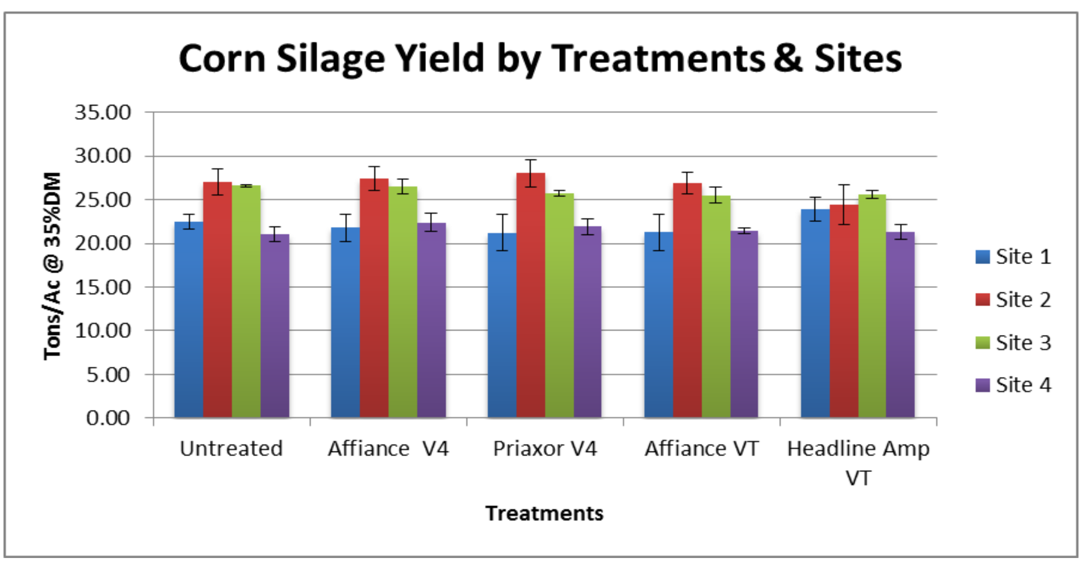


Figure 3. Average corn silage yields by treatments and sites with standard error bars.



Forage Quality
The average results of the forage quality analyses: crop dry matter (DM), crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF), starch, NDF digestibility at 30 hours and indigestible NDF (uNDF) at 240 hours, are summarized by treatment and site in Table 6.

Table 6. Average Values for Forage Quality Factors Evaluated by Site and Treatment

		DM	CP	ADF	aNDF	Starch	NDFDom30	uNDFom240
Site 1	Untreated	33.1	5.5	24.9	41.6	31.7	67.0	8.4
Site 2	Untreated	38.4	7.2	21.4	36.8	36.2	64.1	6.9
Site 3	Untreated	34.2	6.0	24.8	40.8	33.8	60.4	13.8
Site 1	Affiance V4-6	31.8	5.5	24.6	42.6	31.4	71.2	10.2
Site 2	Affiance V4-6	34.5	7.1	21.7	36.7	34.7	64.4	7.1
Site 3	Affiance V4-6	34.1	6.6	22.9	38.2	35.0	60.0	12.7
Site 1	Priaxor V4-6	32.2	5.8	23.9	40.3	33.2	69.3	9.3
Site 2	Priaxor V4-6	33.0	7.4	22.5	37.0	34.8	62.2	7.7
Site 3	Priaxor V4-6	34.3	6.1	22.1	37.1	37.3	57.7	13.0
Site 1	Affiance VT	31.7	5.5	24.5	41.3	32.1	69.8	9.7
Site 2	Affiance VT	33.9	7.0	22.4	36.8	33.9	62.1	7.5
Site 3	Affiance VT	34.4	6.1	24.2	41.4	32.1	58.5	13.2
Site 1	Headline VT	32.3	5.6	23.4	40.2	33.1	68.0	9.1
Site 2	Headline VT	35.2	7.3	21.7	36.8	34.9	66.1	6.5
Site 3	Headline VT	34.9	6.2	22.4	36.9	37.2	57.9	13.0

Statistical analysis (ANOVA) did not detect any differences based on treatments. There were differences between farms. Table 7 summarized the p values for the different quality parameters.

Table 7. Summary Statistics from ANOVA

Factor	**F Ratio**	**Prob >F**
DM	1.53	0.16
CP	4.52	0.0003*
ADF	1.30	0.26
aNDF	2.10	0.0443*

*Indicates difference between farms not treatments

Table 7. *continued*

Factor	**F Ratio**	**Prob >F**
Starch	1.21	0.321
NDFDom30	9.44	<.0001*
uNDFom30	15.73	<.0001*
Mycotoxin (DON)	1.11	0.411

*Indicates difference between farms not treatments

Figures 4-11 show the averages for individual quality factors by treatment for each site.
Figures 12-16 illustrate the quality results by treatment.

Figure 4. Crude Protein (CP)

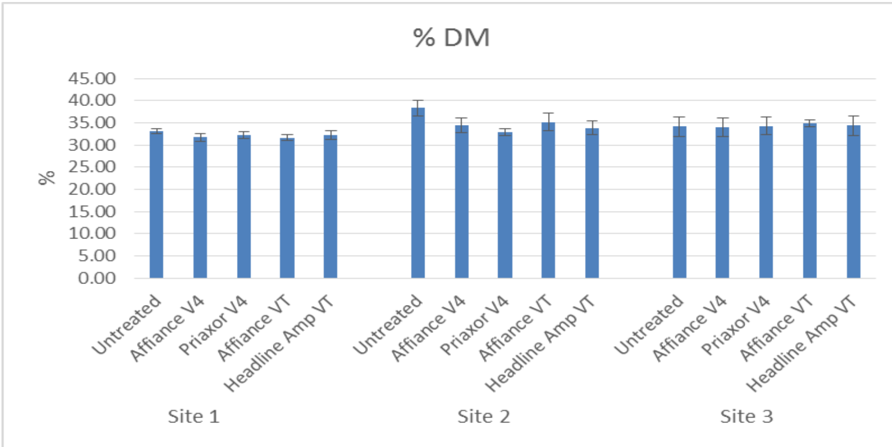


Figure 5. Crude Protein (CP)

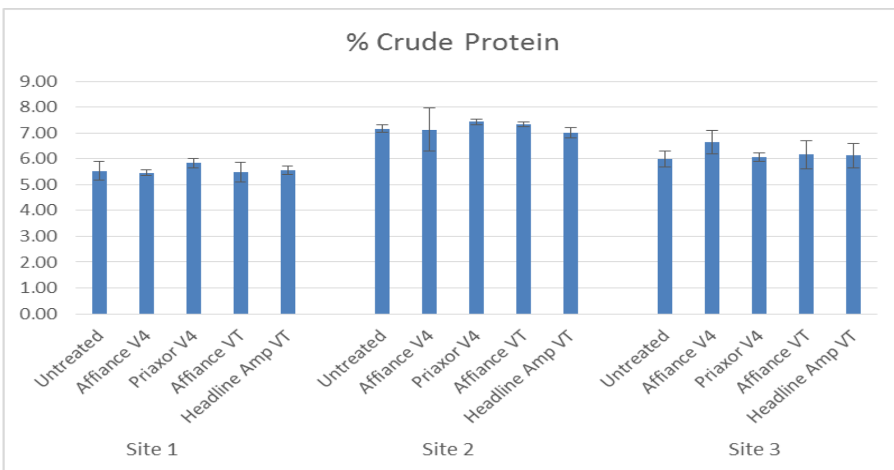


Figure 6. Acid Detergent Fiber (ADF)

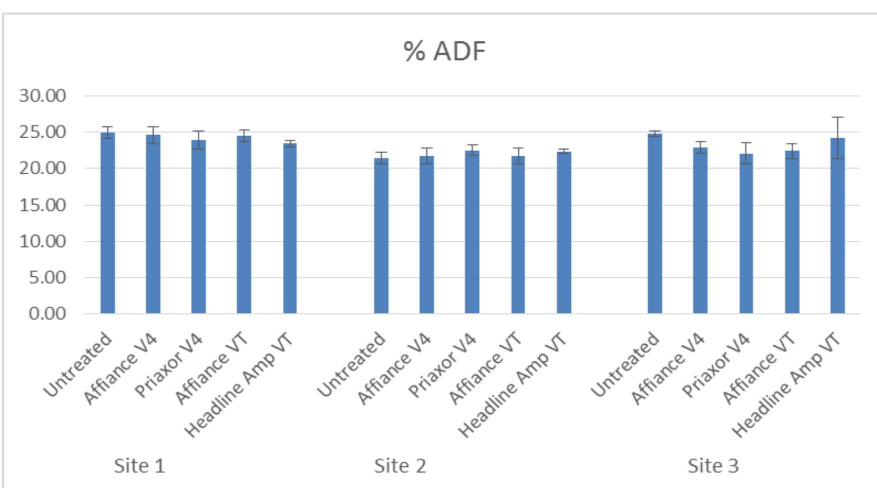


Figure 7. Neutral Detergent Fiber (aNDF)

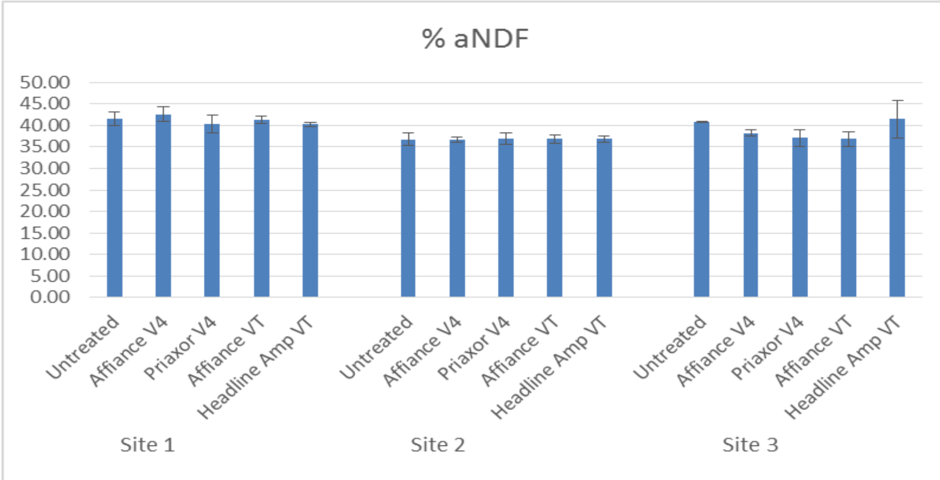


Figure 8. Starch

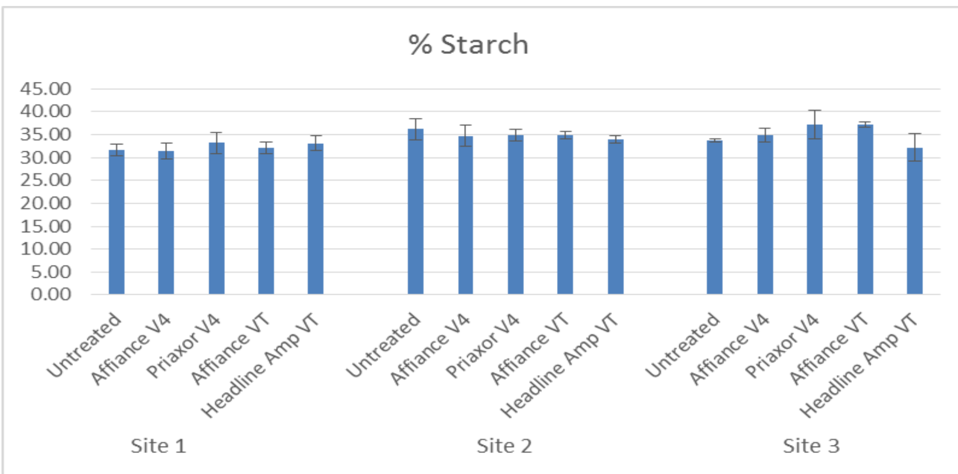


Figure 9. 30 hour digestibility (NDFDom30)

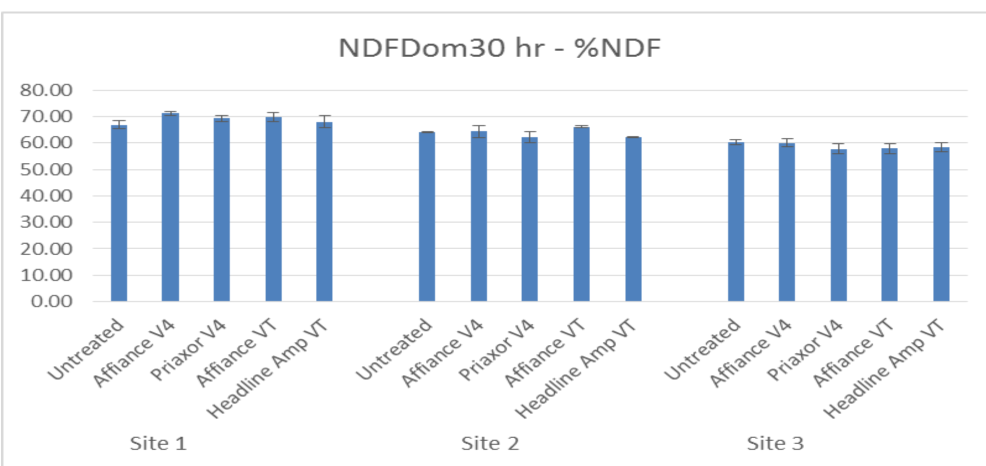


Figure 10. Indigestible NDF-240 hours (uNDFom240)

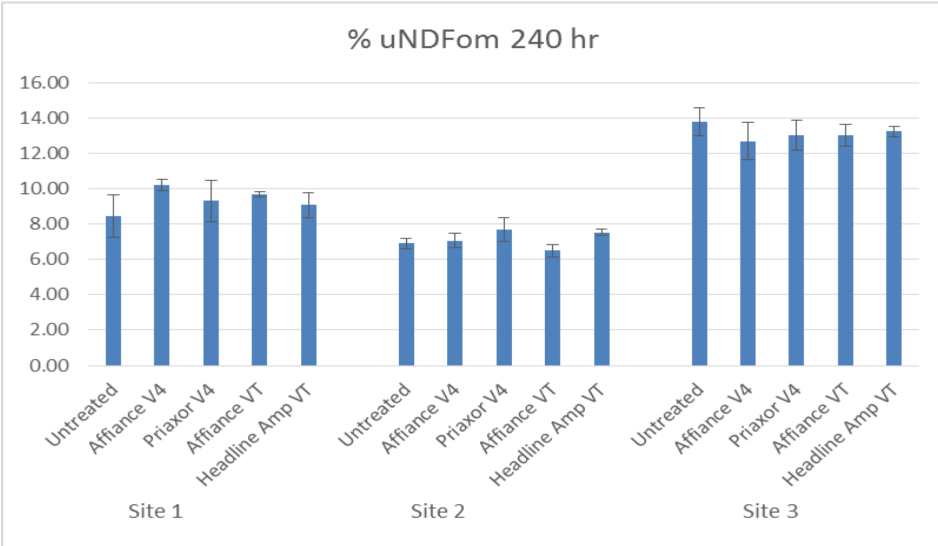
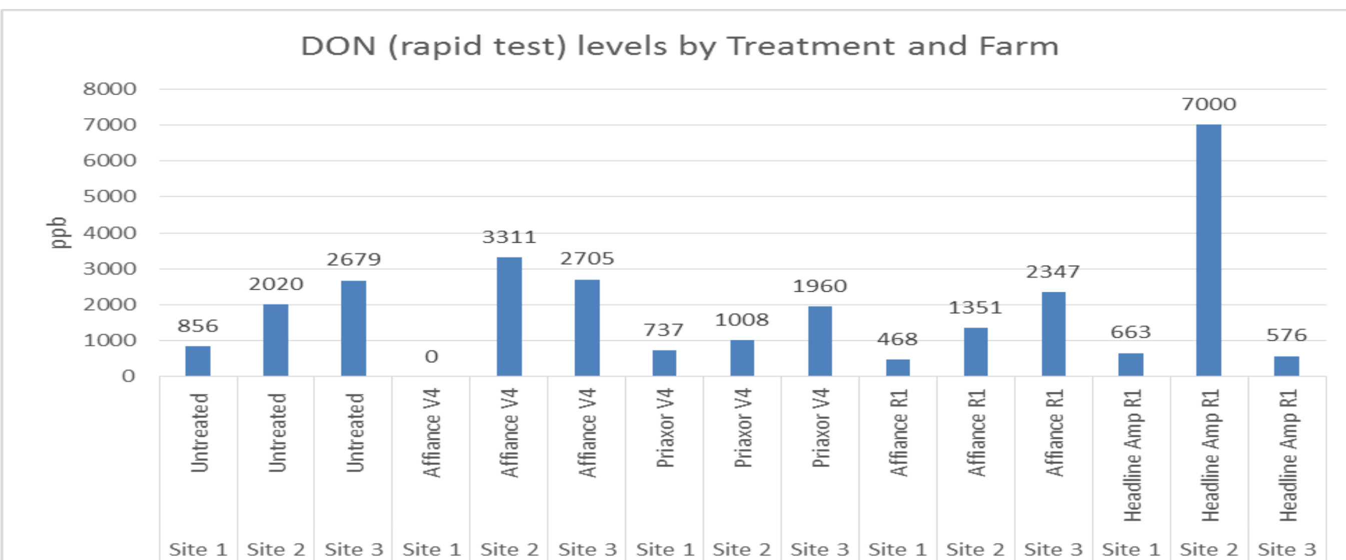


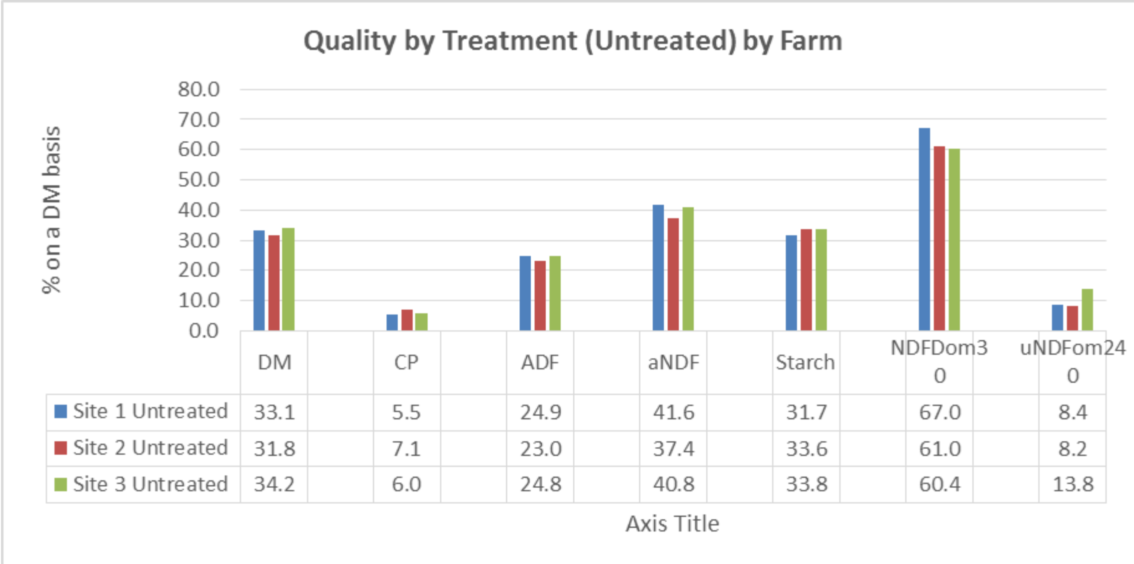
Figure 11. Mycotoxin Test Results for Deoxynivalenol (DON Rapid test)



The mycotoxin levels detected are interesting. Although there is not a clear relationship with treatments this preliminary data indicates a need to collect much more data to better understand the incidence and severity of mycotoxins in our silage crops.

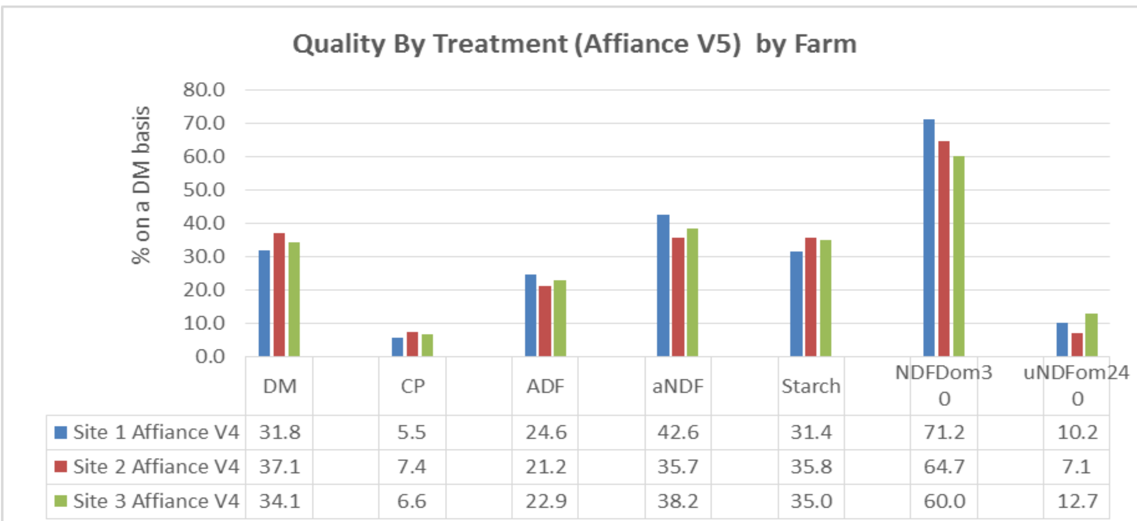
Forage Quality by Treatment by Farm

Figure 12.



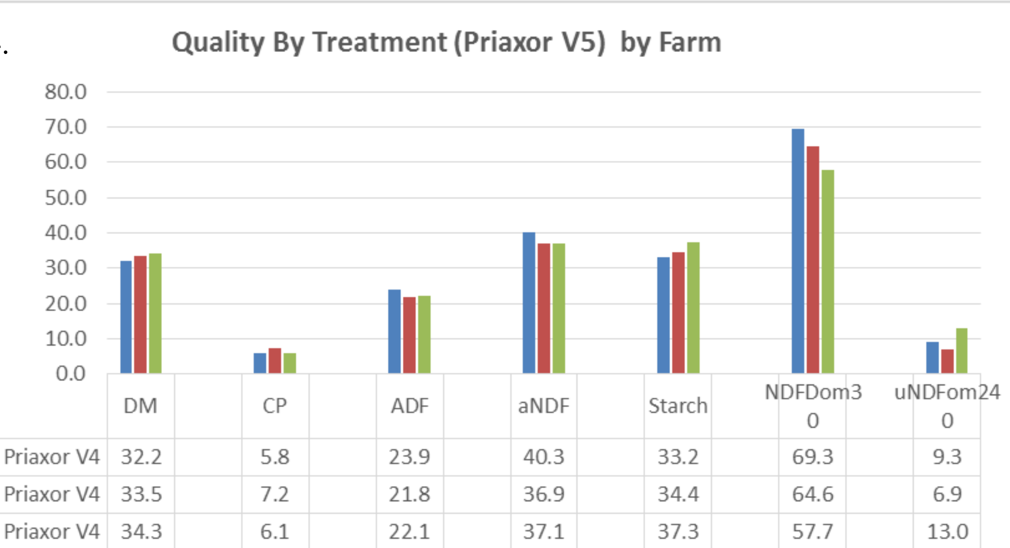
	DM	CP	ADF	aNDF	Starch	NDFDom30	uNDFom240
Site 1 Untreated	33.1	5.5	24.9	41.6	31.7	67.0	8.4
Site 2 Untreated	31.8	7.1	23.0	37.4	33.6	61.0	8.2
Site 3 Untreated	34.2	6.0	24.8	40.8	33.8	60.4	13.8

Figure 13.



	DM	CP	ADF	aNDF	Starch	NDFDom30	uNDFom240
Site 1 Affiance V4	31.8	5.5	24.6	42.6	31.4	71.2	10.2
Site 2 Affiance V4	37.1	7.4	21.2	35.7	35.8	64.7	7.1
Site 3 Affiance V4	34.1	6.6	22.9	38.2	35.0	60.0	12.7

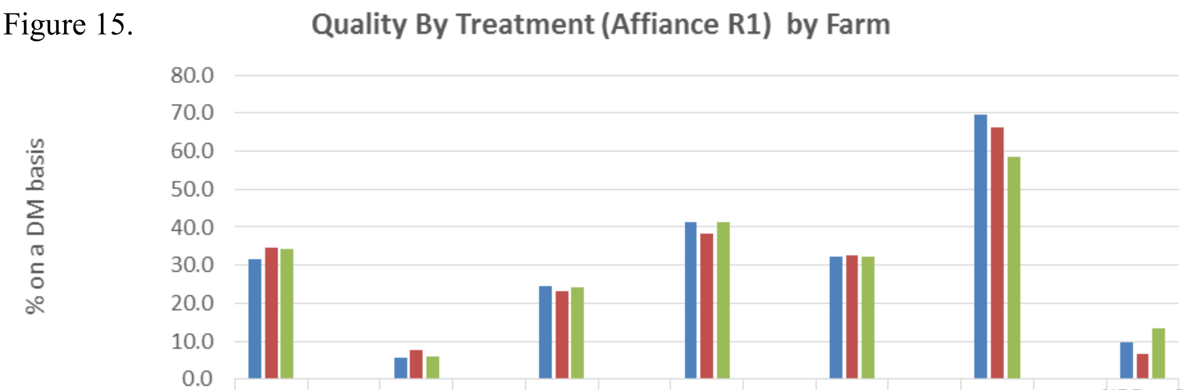
Figure 14.



	DM	CP	ADF	aNDF	Starch	NDFDom30	uNDFom240
Site 1 Priaxor V4	32.2	5.8	23.9	40.3	33.2	69.3	9.3
Site 2 Priaxor V4	33.5	7.2	21.8	36.9	34.4	64.6	6.9
Site 3 Priaxor V4	34.3	6.1	22.1	37.1	37.3	57.7	13.0

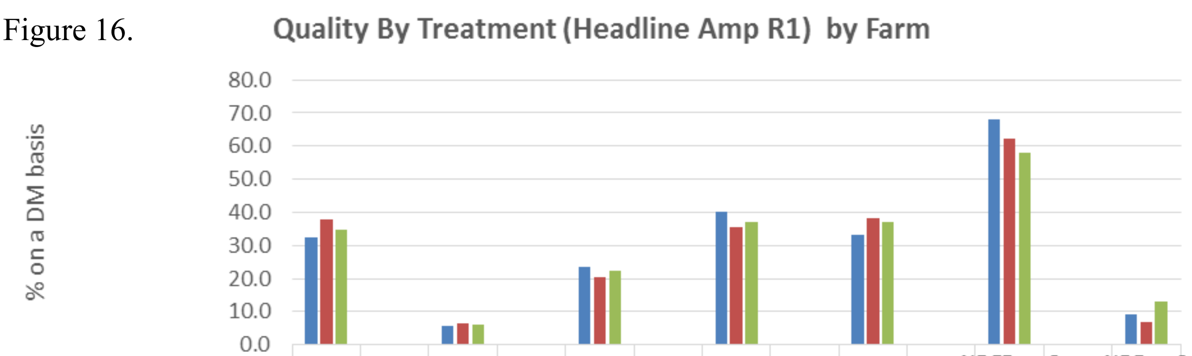
Forage Quality by Treatment by Farm Continued

Figure 15.



	DM	CP	ADF	aNDF	Starch	NDFDom30	uNDFom240
Site 1 Affiance R1	31.7	5.5	24.5	41.3	32.1	69.8	9.7
Site 2 Affiance R1	34.6	7.7	23.1	38.3	32.7	66.3	6.6
Site 3 Affiance R1	34.4	6.1	24.2	41.4	32.1	58.5	13.2

Figure 16.



	DM	CP	ADF	aNDF	Starch	NDFDom30	uNDFom240
Site 1 Headline Amp R1	32.3	5.6	23.4	40.2	33.1	68.0	9.1
Site 2 Headline Amp R1	38.0	6.6	20.5	35.7	38.0	62.4	6.9
Site 3 Headline Amp R1	34.9	6.2	22.4	36.9	37.2	57.9	13.0

Axis Title

Cost-Benefit Analysis

Fungicides are applied to protect yield, and their use generates an additional production expense. An economically sound decision would require the yield enhancement from the fungicide application to exceed the cost of the treatment. Table 8 summarizes the cost of the fungicides used in this study.

Table 8. Estimated retail cost of this trial's fungicides and cost of application per acre.

Fungicide	**Retail Cost per gal & oz**	**Application Rate (oz)**	**Fungicide Cost/ac**	**Total Cost of Fungicide & Application* (@ $12/ac)**
Affiance	$156/gal $1.22/oz	10 oz/ac	$11.22/ac	$33.22
Priaxor	$500/gal $3.91/oz	5 oz/ac	$19.55/ac	$31.55
Headline Amp	$240/gal $1.88/oz	12 oz/ac	$22.56/ac	$34.56
*Application cost based on local custom application fees.				

Corn silage values will vary with the price of corn per bushel and by an area's supply and demand. A relevant average estimate of the value of corn silage is $50/ton from the feed bunk. Since corn silage is fermented we need to account for shrink or loss of dry matter during fermentation. Using a conservative estimate of 10% shrink (Berger 2017), 1.1 tons fresh corn silage needs to be harvested for every finished ton of corn silage in storage. Since the yields reported in this study are fresh silage from the field, we need to adjust the corn silage price to an equivalent value for fresh chopped silage. The equivalent value for fresh silage would be $45.46. Table 9 shows the yield increase needed to justify the cost of treatment based on these reported values.

Table 9. Silage yield T/ac @35% dry matter needed to offset the cost of fungicide treatment

Affiance	Priaxor	Headline Amp
.74 T/ac	.70 T/ac	.76 T/ac

Discussion

This study aimed to assess the impact of different fungicide treatments and application timings on crop yield and forage quality in the presence of Northern Corn Leaf Blight (NCLB). Disease theory explains that three factors, known as the disease triangle, must all be present and create the required conditions to support a particular disease's development (Stevens 1960; Francl 2001). The factors are: (1) a susceptible host, (2) presence of the pathogen, and (3) conducive environmental conditions. If any one of the three factors is absent, or present outside of the pathogen's ideal range, the disease will not thrive. It was surprising that the combination of (1) corn plantings, particularly BMR hybrids, susceptible to NCLB, (2) corn fields known to be likely sources of overwintered NCLB inoculum, and (3) wet and humid growing conditions during the 2017 growing season failed to support widespread development of NCLB.

During a growing season with extremely low NCLB disease pressure, none of the fungicide treatments or application timings that were tested produced a significant increase in yield. There was no statistically significant difference in corn yields among the treatments, and the average yield from untreated plots could not be differentiated from the average yields in any of the fungicide treated plots. Corn yields did vary significantly across sites, which could have been influenced by yield potential of the hybrid, soil and water conditions, and/or other biotic or abiotic stresses (Paul et al, 2011).

"NCLB infection occurs when conidia are exposed to 6-18 hours of leaf wetness and moderate (66-80 °F) temperatures. Susceptible hybrids and high nitrogen soils also increase disease risk."

https://fyi.uwex.edu/fieldcroppathology/files/2010/09/Corn_Foliar_Disease_Cards.pdf

The yield results from this study are consistent with findings from Mallowa et al. (2015) where fungicide treatments in 2011 and 2012 had no significant effect on corn yields compared to an untreated check at four Midwestern sites. Figure 17 is a snapshot of Figure 4 from their study showing a summary of the results of their study done over two years at multiple locations in several states with four different application timings and an untreated check showing that there were very little differences in yield.

Figure 17. Figure 4 from Mallowa et al. (2015)

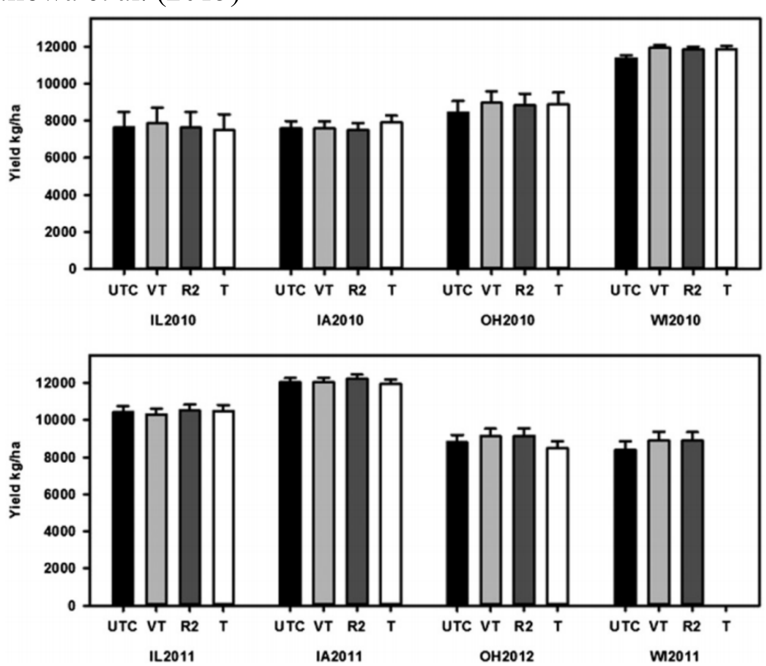


Fig. 4. Effect of fungicide on yield in kilograms per hectare at four sites assessed at time of harvest after physiological maturity between 2010 and 2012. The trial was repeated in 2011 in Illinois, Iowa, and Wisconsin and 2012 in Ohio. Strobilurin fungicide used was Headline (pyraclostrobin), BASF, Research Triangle Park, NC. Treatments were as follows: UTC, an untreated control; VT, VT/R1, single application of strobilurin fungicide applied at anthesis; R2, R2/R3, single application applied at blister/milk growth stage; and T, single application applied based on a threshold foliar disease severity defined as 5% disease severity on the third leaf below the ear leaf or above on 50% of the plants in the plot. IL, Illinois; IA, Iowa; OH, Ohio; and WI, Wisconsin. Wisconsin 2011 had no threshold fungicide application.

Other studies from the Midwest have found crop yield variation in response to fungicide treatments. Figure 18, a replica of Table 3-*Mean yield response of corn due to a fungicide application at four locations in Iowa in 2015* from Robertson and Shriver (2016) provides an example of a range of results from fungicide trials comparing the timing of application and impact on yield. It also shows how often the application paid economically with enough additional yield to cover the cost of the fungicide application. The percent positive yield response varied from 42-82% depending on the application timing. It was lower at the V5 and highest at VT-R1. Two applications at V5 and VT-R1 did not increase yield over the single treatment at VT-R1. Similarly the V5 treatments had the lowest percent of economic yield response (33.3%) while VT-R1 had the highest (62.5%. The combination of an early and late treatment only gave an economic payback 50% of the time.

Figure 18. Table 3 from Robertson and Shriver (2015)

Table 3. Mean yield response of corn due to a fungicide application at four locations in Iowa in 2015

Timing of application	Mean yield response	Range of yield responses	Percent positive yield response	Percent economic yield response[a]
V5 alone	-1.7 bu/A	-23.6 to 8.1 bu/A	41.7	33.3
VT-R1 alone	5.8 bu/A	-1.0 to 25.0 bu/A	91.7	62.5
V5 + VT-R1	6.6 bu/A	-11.5 to 16.2 bu/A	87.5	50.0

[a] Economic response was calculated using corn process of \$3.75/bu and \$25 for the cost of a full rate of fungicide + application. Therefore, the yield response necessary to cover the application of a half rate of fungicide at V5 = 2.0 bu/A; at R1 = 6.7 bu/A and V5 + VT/R1 = 8.7 bu/A.

Studies show that the decision to treat, and the expected results from treatment, are not clear cut (Robertson and Shriver (2015), Robertson and Mueller (2009) and Paul et al. (2011). Recommended considerations for making a decision that provides crop yield protection and a financial payback include
1) scouting to assess disease presence and severity,
2) hybrid disease resistance rating,
3) cost of fungicide and its application,
4) value of the corn, and
5) other factors if corn is to be harvested as grain.

For example, delayed greening as a result of fungicide application can result in wetter corn at harvest potentially increasing drying costs or stand losses from declining stalk strength from delayed harvest.

Further Criteria for fungicide applications is provided by NebFact sheet NF00-428 (Stack 2000).

> The corn plant accumulates approximately 50 percent of the kernel dry matter in the 35 days preceding black layer and the upper 8-10 leaves contribute at least 75 percent of the carbohydrate that goes into the grain. Hence, it is necessary to protect the upper leaves until at least the late dough to dent stages. It is important then to monitor disease development with respect to plant development. Diseases differ with respect to rates of development and the environmental conditions that promote development.

In our study, because there were no significant yield increases attributed to the fungicide treatments, there was no economic justification supporting the use of fungicides in our study sites during the 2017 growing season. However, during a year with greater NCLB disease pressure, there may be sites at which fungicide use is fully economically justified.

Recommendations for Managing Northern Corn Leaf Blight

This study did not find yield benefits from fungicide use in a year with little to no disease pressure. There were no gains that could be attributed to plant health benefits, nor gains to several different components of forage quality.

It appears that the prophylactic use of fungicides is difficult to justify when comparing the costs and benefits of application. Another negative cost that is more difficult to quantify is providing resistance pressure to the disease organism when disease incidence is non existent or arrives late and is limited in scope. To practice both environmental and fiscal responsibility, NCLB presence should be verified and quantified. Current land grant recommendations are practical and provide reliable guidelines.

The following are the scouting guidelines outlined in the *Identification and Management Field Guide for Corn Foliar Diseases* by the land grant consortium of Iowa State University-University Extension, the University of Wisconsin at Madison, University of Illinois at Urbana-Champagne, and the Ohio State University Extension.

> Fungicide applications can be a component of an integrated approach to manage foliar diseases of corn. However, it is important to consider several factors before deciding on a fungicide application.
>
> 1) Scouting is essential. Just before tassel emergence, examine plants for disease symptoms from several locations in each field. Management decisions should be based on symptoms present and on a field-by-field basis.
>
> 2) Know your field history of disease.
>
> 3) Know your hybrid's susceptibility to diseases. Fungicide sprays generally are not recommended for resistant hybrids. For susceptible hybrids, fungicides should be considered if symptoms are present on the third leaf below the ear or higher on at least 50% of the plants.
>
> For hybrids with intermediate levels of disease resistance, fungicides should be considered if symptoms are present on the third leaf below the ear or higher on at least 50% of the plants, at least 35% of the soil surface is covered with corn residue, the previous crop was corn, and weather is favorable for foliar fungal diseases.
>
> 4) Proper diagnosis is important. Fungicides do not control bacterial diseases such as Goss's and Stewart's wilt, and
>
> 5) The use of fungicides may result in higher grain moisture. This can lead to increased costs associated with drying.

Other crop management practices that can reduce the incidence or damage from NCLB include:

- Select a hybrid with a moderate to high resistance rating for built in protection that will slow disease progress and preserve green tissue
- Reduce the source of inoculum in the field through tillage or practices that support the decomposition of stubble under conservation or no-tillage.

Dr. Gary Bergstrom, NYS Extension Field Crops Plant Pathologist, recommends leaving non-sprayed strips to compare yield and disease severity when fungicides are used to be able to evaluate their effectiveness

References:

Berger. A. 2017. Is your corn worth more as grain or silage? Cropwatch. University of Nebraska-Lincoln. https://cropwatch.unl.edu/2017/your-corn-worth-more-grain-or-silage-calculations

Bergstrom, G. Management of Corn Diseases in NY. https://fieldcrops.cals.cornell.edu/corn/diseases-corn/corn-disease-management/

Francl, L.J. 2001. The Disease Triangle: A plant pathological paradigm revisited. *The Plant Health Instructor*. DOI: 10.1094/PHI-T-2001-0517-01. Reviewed 2007 https://www.apsnet.org/edcenter/instcomm/TeachingArticles/Pages/DiseaseTriangle.aspx

Kharel, T., S.N. Swink, C. Youngerman, A. Maresma, K.J. Czymmek, Q.M. Ketterings, P. Kyveryga, J. Lory, T.A. Musket, and V. Hubbard (2018). Processing/Cleaning Corn Silage and Grain Yield Monitor Data for Standardized Yield Maps across Farms, Fields, and Years. Cornell University, Nutrient Management Spear Program, Department of Animal Science, Ithaca NY.

Mallowa, Sally O., Paul D. Esker, Pierce A. Paul, Carl A. Bradley, Venkata R. Chapara, Shawn P. Conley, and Alison E. Robertson. 2015. Effect of Maize Hybrid and Foliar Fungicides on Yield Under Low Foliar Disease Severity Conditions. Phytopathology 2015 105:8, 1080-1089. https://apsjournals.apsnet.org/doi/full/10.1094/PHYTO-08-14-0210-R

Nielsen, R.L., Kiersten Wise and Corey Gerber. 2008. Arrested Ears Resulting from Pre-'Tassel Applications of Pesticide and Spray Additive Combinations. Agronomy Dept. Botany & Plant Pathology Dept. Purdue Univ. West Lafayette, IN. https://www.agry.purdue.edu/ext/corn/news/articles.08/arrestedears-1209.html

Northeast Regional Climate Center. Northeast Overview: April – October 2017. *http://www.nrcc.cornell.edu/services/blog/2017/05/16/index.html and http://www.nrcc.cornell.edu/regional/narrative/narrative.html*

Paul, P. A.; Madden, L. V.; Bradley, C. A.; Robertson, A. E.; Munkvold, G. P.; Shaner, G.; Wise, K. A.; Malvick, D. K.; Allen, T. W.; Grybauskas, A.; Vincelli, P.; and Esker, P., "Meta-Analysis of Yield Response of Hybrid Field Corn to Foliar Fungicides in the U.S. Corn Belt" (2011). *Plant Pathology and Microbiology Publications*. 229. https://lib.dr.iastate.edu/plantpath_pubs/229

Price, T., Purvis, M., Pruitt, H. 2016. A Quantitative Disease Severity Rating Scale for Northern Corn Leaf Blight. Plant Health Progress: Vol.17. No. 1. p.49. http://www.plantmanagementnetwork.org/pub/php/volume17/number1/PHP-BR-16-0010.pdf

Robertson, A. and S. Shriver. 2016. 2015 Evaluations of Fungicides on Corn at Four Iowa Locations. Iowa State University Extension and Outreach. https://crops.extension.iastate.edu/cropnews/2016/06/2015-evaluation-foliar-fungicides-corn-four-iowa-locations

Salgado, J.D., Schoenhals, J., and Pierce, A.P. 2016. Northern Corn Leafblight. Ohioline. PLPATH-CER-10. https://ohioline.osu.edu/factsheet/plpath-cer-10

Stack, Jim. 2000. Extension Plant Pathologist. Fungicide Management of Foliar Diseases of Corn. NebFact Nebraska Cooperative Extension NF00-428. https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1890&context=extensionhist

Stevens, R.B. 1960. Pages 357-429 in: Plant Pathology, an Advanced Treatise, Vol. 3. J.G. Horsfall and A.E. Dimond, eds. Academic Press, NY.

Wise, Kiersten. 2011. Disease of Corn. Northern Corn Leaf Blight. Purdue Extension. Purdue University. BP-84-W. https://www.extension.purdue.edu/extmedia/BP/BP-84-W.pdf

Corn Foliar Diseases Identification and Management Field Guide published by the University Extension at Iowa State University-University Extension, the University of Wisconsin at Madison, University of Illinois at Urbana-Champaign, and the Ohio State University Extension (https://fyi.uwex.edu/fieldcroppathology/files/2010/09/Corn_Foliar_Disease_Cards.pdf)

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Cornell Cooperative Extension colleagues, Mike Hunter and Aaron Gabriel assisted with plot management expanding our coverage across regions in the state. Statistics consulting and mentoring were critical from Dr. Kitty O'Neal and Deniz Akdemir with the Cornell Statistical Consulting Unit. Dr. Quirine Ketterings provided assistance through her post-doc Tulsi Kharel, who was instrumental in translating the yield data. Team members Melanie Palmer and summer intern Alison Parrott assisted with data collection from the 3 SCNY sites. Mary Kate Wheeler, Farm Business Management Specialist with the SCNY Dairy and Field Crops Team provided indispensable editing.

Guide to Appendices

APPENDIX I.   OVERVIEW OF THE WEATHER 2017

To provide an overview of the growing season's weather, I am reprinting excerpts from the National Weather Service's report from May through September 2017. All of the fields in this study were harvested by the 5th of October. Conditions from Syracuse, NY are highlighted because it is the weather station closest to the trial sites and best represents the conditions found at the 3 cooperating farms. [The "normal" referenced in the text that follows is based on 29 years of data from 1981-2010.

"April started off warmer than normal but with excessive precipitation in the first half of the month , up to nearly 200% of normal in our area, waterlogged soils and stalled planting progress. Syracuse ranked 155% of normal with 4.95 inches of rain, the 8th wettest year. Syracuse was 4 degrees above normal and the 7th warmest on record.

The Northeast had its second warmest April on record with an average temperature of 50.5 degrees F (10.3 degrees C), 4.4 degrees F (2.4 degrees C) above normal. This was only 0.2 degrees F (0.1 degree C) behind April 2010, which is the warmest April on record. At the state level, this April was the 3rd warmest for New York.

During April, the Northeast received 3.87 inches (98.30 mm) of precipitation, which was 106 percent of normal. New York had its 14th wettest April on record.

With an average temperature of 55.5 degrees F (13.1 degrees C), May was 0.8 degrees F (0.4 degrees C) colder than normal in the Northeast. Despite a cold March and below-normal temperatures in May, a record warm April helped the Northeast average out to be 46.0 degrees F (7.8 degrees C) during spring, 0.4 degrees F (0.2 degrees C) warmer than normal. On May 18, LaGuardia Airport, New York, and Burlington, Vermont, tied their warmest spring temperatures on record with highs of 97 degrees F (36 degrees C) and 93 degrees F (34 degrees C), respectively.

The Northeast ended May on the wet side of normal. The region received 5.53 inches (14.05 mm) of precipitation, 137 percent of normal, making it the eighth wettest May since 1895. All twelve states received above-normal precipitation, with ten ranking this May among their top 20 wettest: New York, 13th wettest;

The Northeast had its sixth wettest spring since recordkeeping began. Each of the twelve states was wetter than normal, New York, sixth wettest.

For most of the Northeast, May started off chilly, warmed up mid-month, then wrapped up on the cool side. From May 17-19, several sites had one of their top five warmest spring days on record as high temperatures reached 90°F or above. In fact, LaGuardia Airport, NY, and Burlington, VT, tied their warmest spring temperatures on record with highs of 97°F and 93°F, respectively. Overall, May average temperatures ranged from 3°F below normal to 2°F above normal, with temperatures in most areas near to below normal. The coolest spots were generally in portions of New York and New England, while the warmest spots were generally in West Virginia. Of the region's 35 major climate sites, 21 were cooler than normal in May, with Worcester, MA, having its 20th coldest.

"Mid-May - Rain Boots Required"
It was a soggy May, with much of the Northeast seeing from 100% to 200% of normal precipitation.

"The first week of May was quite wet across the Northeast, Syracuse, NY have seen more than 90% of their normal May precipitation already.
From May 1-15 precipitation in Syracuse was 212% of normal while average temperature were 6.1% cooler.
May total precipitation was 201% of normal at 6.46 inches (3.22" normal), and ranked as the third wettest year on record.
May 1-15 average temperatures have been colder than normal for most of the Northeast, with the coolest spots of more than 6°F below normal in western New York.
The first half of May has been chilly in the Northeast. Average temperatures ranged from near normal to more than 6°F below normal, with a large portion of the region being 2°F to 6°F below normal. All but one of the region's 35 major climate sites were colder than normal, with 15 ranking this first half of May among their top 20 coldest.

An Indecisive June
June couldn't decide if it wanted to be wet or dry, cold or hot, so it was all of it!

June featured a few cool downs and warm ups. At six major climate sites, high temperatures on June 6 ranged from 49°F to 60°F, which ranked among the top five coldest high temperatures on record for summer. On June 13, LaGuardia Airport, NY, tied its all-time warmest June day on record when it reached 101°F. In the end, temperatures averaged out to be from 2°F below normal to 2°F above normal for most of the region for June. In Syracuse June average temperature was 65.9 a departure of .8 degrees from normal

June precipitation was variable, with more than 200% of normal in northern New York. Central NY was wet with Syracuse receiving 4.69 inches of rain (142% of normal).

During the first half of summer (June 1- July 15), precipitation ranged from 25% to 200% of normal, with much of the region on the wet side of normal. The driest areas were in coastal Maine and central Maryland, while the wettest areas were generally in western Pennsylvania, upstate New York, central Vermont, and northern Rhode Island. Ten of the 25 wetter-than-normal major climate sites ranked this first half of summer among their top 20 wettest.

Raindrops Keep Falling…or Not

July is the hottest month, with normal max temperatures ranging from the mid-70s to the upper 80s across the region. At the 35 major climate sites, mean max temperatures range from 76.0°F in Caribou, ME, to 88.4°F at Washington National, DC. The highest July temperature in Syracuse was 102°F. July is the month (or tied with other months) with the all-time highest average temperature at all but one major climate site.

A large portion of the Northeast was wetter than normal during the first two weeks of July, receiving 100% to more than 200% of normal rainfall. The precipitation frequently fell in quick, heavy bursts, resulting in flash flooding in some areas. Between July 1 -15 Syracuse logged 2.99 inches of rain which was 164% of normal and ranked 14th wettest.

At the major climate sites, June 1 - July 15 average temperatures ranged from 0.6°F below normal in Syracuse, NY, to 2.4°F above normal at Washington National, DC.

During the first half of July 1-15 Syracuse received 7.68 inches of rain (5.13 normal) 150% above normal and the 17th wettest year. Temperatures were right on the button for normal averaging 71.1 degrees.
During the first half of summer (June 1- July 15), precipitation ranged from 25% to 200% of normal, with much of the region on the wet side of normal. The driest areas were in coastal Maine and central Maryland, while the wettest areas were generally in western Pennsylvania, upstate New York, central Vermont, and northern Rhode Island. Ten of the 25 wetter-than-normal major climate sites ranked this first half of summer among their top 20 wettest.

Chillin' in Mid-August

August 1-15 average temperatures ranged from more than 3°F below normal to 3°F above normal.

The Northeast has generally been colder than normal during the first half of August, with average temperatures in many areas ranging from more than 3°F below normal to normal. The coldest areas tended to be in southern portions of the region. However, some parts of northern New York, Massachusetts, and northern New England have seen average temperatures ranging from normal to 3°F above normal. The warmest area was northwestern Vermont. Thirty of the region's 35 major climate sites were colder than normal, with six sites ranking this first half of August among their top 20 coldest.

The average temperature for the first 15 days of August in Syracuse was 70.5^0, 0.3^0 less than normal.
August precipitation varied, generally ranging from 25% of normal to 200% of normal. Syracuse was on the dry side with 1.8 inches of precip, 50% of normal and the 16th driest August.

August average temperatures generally ranged from more than 3°F below normal to 1°F above normal.
The last month of meteorological summer was a cool one for the Northeast, with average temperatures ranging from 3°F below normal to normal for most areas. Thirty-two of the region's 35 major climate sites were colder than normal, with Binghamton, NY, Dulles Airport, VA, and Baltimore, MD, ranking this August among their top five coldest on record.

Average temperatures for August at the major climate sites ranged from 2.8°F below normal in Binghamton, NY, to 0.6°F above normal in Burlington, VT.
Syracuse averaged 68.2°F, 1.6°F below normal.

June-August Summary

Summer average temperatures ranged from 3°F below normal to 2°F above normal in the region.
There were a few cooler spots that were 2-3°F colder than normal, as well as a few warmer locations that were up to 2°F warmer than normal, but overall summer averaged out to be within 1°F of normal for a large portion of the region. Of the 35 major climate sites, 19 were warmer than normal, 14 were colder than normal, and two

wrapped up the season at normal. Atlantic City, NJ, and Washington, DC, ranked this summer among their top 20 warmest, while Binghamton, NY had its 9th coldest summer on record.

August was dryer than normal in Syracuse with only 1.8 inches of rain which is 50% of normal (3.57”) and was ranked the 16th driest year.

September - Turning Over a New Leaf

The first month of autumn started off on the cold side, with temperatures ranging from normal to **more than 6°F** below normal for much of the Northeast. However, the second half of the month featured a big warm up, with record-setting heat moving into the region around September 23. High temperatures pushed into the upper 80s and low 90s. These temperatures were the warmest temperatures all year for sites like Binghamton, NY, and Rochester, NY.

With the cold start and late-month heat, September averaged out to be warmer than normal for a majority of the region. Average temperatures generally ranged from normal to more than 6°F above normal. Thirty-three of the region’s 35 major climate sites had an above-normal average temperature for September, with 22 ranking this September among their top 20 warmest on record.

September was a drier-than-normal month, with precipitation ranging from 25% of normal to 100% of normal for most of the Northeast. There were a few spots scattered throughout the region that were wetter than normal. Above-normal temperatures combined with below-normal precipitation contributed to the expansion and introduction of abnormally dry conditions in the Northeast. Thirty-one of the 35 major climate sites were drier than normal, with twelve of them ranking this September among their top 20 driest on record. Thirty-one of the 35 major climate sites were drier than normal, with twelve of them ranking this September among their top 20 driest on record.

Syracuse’s average temperature for the month of September was 64.5°F, a 2.5°F departure the normal of 62°F.

Syracuse received 1.38 inches of rain, 37% of normal, which is 3.69 inches and was ranked the 13th driest September.

All 35 stations were warmer than normal for the September 1 to October 15 period, with seven being record warm. Departures were up to 6.5°F above normal.

From September 1-October 15, Syracuse averaged 63.4°F (normal: 59.1°F) or +4.3°F departure from normal and the 7th warmest on record.”

References:

Source: Northeast Regional Climate Center. Northeast Overview: April – October 2017. *http://www.nrcc.cornell.edu/services/blog/2017/05/16/index.html and http://www.nrcc.cornell.edu/regional/narrative/narrative.html*

Precipitation and Temperatures for Syracuse, NY from April through mid-October are summarized in Tables 1 and 2 that follow. Syracuse is the weather station closet to the trial sites and represents the conditions found at the 3 cooperator farm fields in the South Central NY region.

Table 1. 2017 Precipitation recorded in Syracuse, NY by the Northeast Regional Climate Center

2017	Precipitation (in)	Normal (in)	Percent of Normal	Rank	Comments
April 1-15	3.04	1.68	181%	3 (wettest)	
April	4.95	3.19	155%	8 (wettest)	*April precipitation was near to above normal for a majority of the Northeast.*
May 1-7	2.94	3.22	91%	3 (wettest)	
May 1-15	3.16	1.49	212%	5 (wettest)	
May 1-31	6.46	3.22	201%	3 (wettest)	*May was wetter than normal for almost the entire Northeast.*
March 1 – May 1	15.26	9.36	163%	4(wettest)	*Spring precipitation at the major climate sites ranged from 95% of normal in Huntington, WV, to 184% of normal in Rochester, NY.*
June 1-15	2.12	1.65	128%		*June 1-15 precipitation ranged from less than 25% of normal to more than 150% of normal, with many areas on the dry side of normal.*
June	4.69	3.31	142%		
July 1-15	2.99	1.82	164%	14 (wettest)	
July 1-31	4.19	3.78	111%		
June 1 – July 15	7.68	5.13	150%	11 (wettest)	
August 1 - 15	.88	1.72	51%		*August 1-15 precipitation ranged from less than 25% of normal to more than 200% of normal.*
August 1 – 31	1.80	3.57	50%	16th driest	*August precipitation at the major climate sites ranged from 41% of normal in Providence, RI, to 229% of normal in Allentown, PA.*
June - August	10.68	10.66	100%		*Summer precipitation ranged from 50% of normal to 200% of normal for much of the Northeast.*
September 1 -15	1.22	1.78	69%		*September 1-15 precipitation ranged from 34% of normal in Pittsburgh, PA, to 257% of normal in Atlantic City, NJ.*
September 1 -30	1.38	3.69	37%	13th (driest)	*September precipitation ranged from 25% of normal to more than 200% of normal, with most areas being drier than normal.*
October 1-15	1.82	1.69	108%		*Precipitation has been variable so far this October*
September 1 - October 15	3.2	5.38	59%		Most of the Northeast has been drier than normal for the September 1 to October 15 period, with most areas seeing 50% to 100% of normal precipitation.

Table 2. 2017 Average Temperature recorded in Syracuse, NY by the Northeast Regional Climate Center					
Date	**Avg Temp (^{0}F)**	**Normal (^{0}F)**	**Departure (^{0}F)**	**Rank**	**Comments**
April 1-15	47.5	43.9	3.6	11 (warmest)	
April	50.9	46.9	4.0	3 (warmest)	April average temperatures were warmer-than-normal for the entire Northeast.
May 1-15	49.0	55.1	-6.1	8 (coldest)	*May 1-15 average temperatures have been colder than normal for most of the Northeast, with the coolest spots of more than 6°F below normal in western New York.*
May 1-31	55.7	57.6	-1.9		*A large portion of the Northeast saw near- to below-normal May average temperatures.*
March 1 –May 1	45.6	46.2	-0.6		At the major climate sites, spring average temperatures ranged from 1.3°F below normal in Worcester, MA, to 3.1°F above normal in Elkins, WV.
June 1-15	63.6	64.7	-1.1		*June 1-15 average temperatures at the major climate sites ranged from 1.1°F below normal in Syracuse, NY, to 2.2°F above normal in Pittsburgh, PA.*
June	65.9	66.7	-0.8		June temperatures at the major climate sites ranged from 0.8°F below normal in Charleston, WV, and Syracuse, NY to 2.3°F above normal in Bridgeport, CT.
July 1-15	71.1	71.1	0.0		Average temperatures so far this July at the major climate sites ranged from 0.5°F below normal in Worcester, MA, to 3.0°F above normal in Atlantic City, NJ.
July 1 – 31	70.3	71.3	-1.0		July average temperatures for the major climate sites ranged 1.0°F below normal in Syracuse, NY, and 2.2°F above normal in Williamsport and Allentown, PA.
June 1- July 15	67.6	68.2	-0.6		At the major climate sites, June 1 - July 15 average temperatures ranged from 0.6°F below normal in Syracuse, NY, to 2.4°F above normal at Washington, DC.
August 1 - 15	70.5	70.8	-0.3		
August 1 – 31	68.2	69.8	-1.6		*August average temperatures generally ranged from more than 3°F below normal to 1°F above normal.*
June-August	68.1	69.3	-1.2		*Average temperatures for summer at the major climate sites ranged from 1.4°F below normal in Binghamton, NY, to 1.1°F above normal at four sites.*
September 1-15	60.6	64.9	-4.3	11 (coldest)	*September 1-15 average temperatures ranged from more than 6°F below normal to 2°F above normal.*
September 1-30	64.5	62.0	2.5		*While most of the Northeast was warmer than normal in September, overall, average temperatures ranged from 2°F below normal in parts of West Virginia to more than 6°F above normal in parts of Maine.*
October 1-15	61.1	53.3	7.8	4th warmest	*October has been warmer than normal for the entire Northeast, with most areas 4°F to 10°F above normal.*
Sept 1- Oct 15	63.4	59.1	4.3	7th warmest	*All 35 stations were warmer than normal for the September 1 to October 15 period, with seven being record warm. Departures were up to 6.5°F above normal.*

APPENDIX II. Understanding Forage Quality Factors

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Understanding & Significance of Forage Analysis Results
(Unless otherwise noted, the following information pertains to ruminants, cattle in particular).

Moisture – the percent water in a sample.

Dry matter – equals (100% - Moisture) and represents everything in the sample other than water including protein, fiber, fat, minerals, etc. Animals consume feeds to meet their dry matter needs, because it is the dry matter that contains all of the nutrients. Therefore, animals will have to consume more of a wetter feed to receive the same amount of dry matter as they would from a drier feed. For example, if an animal consumes 20 lbs. of hay at 90% dry matter, it consumes 18 lbs. of dry matter (20 x .90). If haylage at 40% dry matter was to be substituted for the hay, it would have to consume 45 lbs. of haylage (18/.40) to receive the same amount of dry matter.

Thus, it is very important to know the dry matter content of a feed to establish feeding rates and insure that livestock receive the proper amount of feed to meet their daily needs.

As Sampled Basis – nutrient results for the sample in its natural state including the water. Also known as fed or as received.

Dry Matter Basis – nutrient results for the sample with the water removed. There is considerable variation in the moisture content of forages. Removing the water eliminates the dilution effect of the water thereby enabling direct comparisons of nutrient contents across different forages. For example, suppose that you wanted to compare the protein content of a hay testing 90% dry matter to a haylage testing 40% dry matter. On an as sampled basis the hay tested 14% crude protein (CP) and the haylage 8% CP. The hay appears to have the higher CP level. However, removing the dilution effect of the water reveals that the hay is 15.5% CP (14/.90) and the haylage is 20% CP (8/.40) on a dry matter basis. Thus, removing the dilution effect of the water revealed that per pound of dry matter, the haylage is higher in protein. Animals eating the haylage will consume more protein per pound of dry matter than they will from the hay.

Livestock nutrient requirements may be expressed on either an as sampled or dry matter basis. It is important to use analytical results expressed on the same basis as the nutrient requirements. In general, most livestock requirements are expressed on a dry matter basis; therefore, theforage results on a dry matter basis should be used to balance the ration. Again, the key point is to make sure that the requirements and results are expressed on the same basis.

Protein and Protein Fractions

Crude Protein (CP) – the total protein in the sample including true protein and non-protein nitrogen. Proteins are organic compounds composed of amino acids. They are a major component of vital organs, tissue, muscle, hair, skin, milk and enzymes. Protein is required on a daily basis for maintenance, lactation, growth and reproduction. Proteins can be further fractionated for ruminants according to their rate of breakdown in the rumen.

Urea and Ammonia – reported as crude protein equivalent (CPE). Urea and ammonia are not proteins. However, they contain nitrogen that can be used by the microbial population in the rumen to synthesize protein. They are classified as non-protein nitrogen (NPN). Thus, although they are not true proteins, they supply nitrogen which can be used to form microbial protein and therefore have a certain value that is equivalent to protein for ruminants. The reported result is the CPE contribution from each of these compounds. The results are not the percent urea or ammonia in the feed. The actual percentage in the feed can be calculated by dividing the urea CPE by 2.81 or the ammonia CPE by 5.15. The urea and ammonia appear in the soluble protein fraction of the protein.

Soluble Protein (SP) – proteins and non-protein nitrogen that are rapidly broken down in the rumen. They are used to synthesize microbial protein in the rumen.

Degradable Protein (RDP) – consists of the soluble protein and proteins of intermediate ruminal degradability. They are used to synthesize microbial protein in the rumen.

Undegradable Protein (RUP) – proteins that have a slow rate of degradability and escape digestion in the rumen. UIP is also known as escape or bypass protein and reaches the lower gastrointestinal (GI) tract essentially intact. The undegradable protein is broken down in the GI tract as it would be in nonruminants.

Acid Detergent Insoluble Crude Protein (ADICP) – also known as heat damaged or unavailable protein. Typically caused by heating during fermentation or drying, a portion of the protein reacts with carbohydrates to form an indigestible complex rendering it unavailable for digestion. ADICP escapes ruminal breakdown and represents the portion of the undegradable protein that is unavailable to the animal.

Neutral Detergent Insoluble Crude Protein (NDICP) – it has been suggested that the NDICP represents the portion of the undegradable protein that is available to the animal.

Carbohydrates

Neutral Detergent Fiber (NDF) – a measure of hemicellulose, cellulose and lignin representing the fibrous bulk of the forage. These three components are classified as cell wall or structural carbohydrates. They give the plant rigidity enabling it to support itself as it grows, much like the skeleton in animals. Hemicellulose and cellulose can be broken down by microbes in the rumen to provide energy to the animal. NDF is negatively correlated with intake.

aNDF –analyzing samples high in protein and/or starch may lead to an overestimation of the NDF value. The neutral detergent solution washes out the majority of protein and starch during the digestion phase of the analysis. Samples high in protein or starch can overwhelm the extraction such that all of the protein or starch are not removed. The addition of sodium sulfite and amylase to the NDF procedure will help wash out the protein and starch, respectively. The removal of the protein/starch contamination will lead to a better measure of true fiber. The "a" designates that the analysis was performed with the addition of sodium sulfite and amylase.

aNDFom – aNDF analyses performed with the addition of an ashing step to remove inorganic materials such as minerals, soil, and sand (collectively, ash) by burning (ashing) the fibrous residue at 550oC for 2 hours. The neutral detergent solution washes out the majority of ash during the digestion phase of the analysis. Samples high in ash can overwhelm the extraction such that all of the ash is not removed. The ash residue will artificially inflate the aNDF result. To eliminate the ash contamination, the fiber residue is ashed at the end of the procedure. The "ash free" result is reported as aNDFom with the "om" signifying that the result is on an organic matter or ash free basis.

Acid Detergent Fiber (ADF) – a measure of cellulose and lignin. Cellulose varies in digestibility and is negatively influenced by the lignin content. As lignin content increases, digestibility of the cellulose decreases. ADF is negatively correlated with overall digestibility.

Lignin – undigestible plant component. Lignin has a negative impact on cellulose digestibility. As lignin content increases, digestibility of cellulose decreases thereby lowering the amount of energy potentially available to the animal.

Crude Fiber (CF) – historical method of fiber analysis used to divide carbohydrates into digestible and indigestible fractions. Crude fiber accounts for most of the cellulose and only a portion of the lignin. It is not the most accurate method for quantifying fiber, particularly for forages. However, given that grains are low in lignin, it is a reasonable estimate of fiber in grains and is still used today as the legal measurement of fiber in grains and finished feeds.

APPENDIX III.   YIELD MONITOR DATA

APPENDIX B. Raw and Consolidated Yield Monitor Data

Site 2. Treatment strips: for Northern corn leaf blight

101, 109, 112: Tr1

102, 106, 113: Tr2

103, 110, 114: Tr3

104, 107, 115: Tr4

105, 108, 111: Tr5

Site 1:

101, 109, 112: Tr1

102, 106, 113: Tr2

103, 110, 114: Tr3

104, 107, 115: Tr4 (Control Tr)

105, 108, 111: Tr5

Plot length 1188 ft, 90 ft wide

Site 3. 8 row chopper, plot 60 ft wide

101, 109, 112: Tr1

102, 106, 113: Tr2

103, 110, 114: Tr3

104, 107, 115: Tr4

105, 108, 111: Tr5

Site 3:

```
Strip (plot) mean and SD, Currie Expt:

   Plot  Trt  Rep    yield       sd
 1:  101 Trt1 Rep1 26.10464 2.445811
 2:  102 Trt2 Rep1 26.06644 2.725565
 3:  103 Trt3 Rep1 26.62000 3.053237
 4:  104 Trt4 Rep1 26.42708 2.557915
 5:  105 Trt5 Rep1 24.50014 2.252284
 6:  106 Trt2 Rep2 25.31368 1.969643
 7:  107 Trt4 Rep2 26.75335 3.602394
 8:  108 Trt5 Rep2 26.17968 2.309546
 9:  109 Trt1 Rep2 25.51854 2.404026
10:  110 Trt3 Rep2 25.61682 2.077135
11:  111 Trt5 Rep3 25.90020 2.292720
12:  112 Trt1 Rep3 25.56665 2.446578
13:  113 Trt2 Rep3 25.38214 3.339241
14:  114 Trt3 Rep3 27.32659 2.536409
15:  115 Trt4 Rep3 26.53775 2.032537
```

```
ANOVA Site 3. Expt:

            Df Sum Sq Mean Sq F value Pr(>F)
Trt          4  3.198  0.7995   1.818  0.219
Rep          2  0.192  0.0958   0.218  0.809
Residuals    8  3.518  0.4397
```

```
Treatment mean and Site3 Expt:
    Trt    yield        sd
1: Trt1 25.72994 0.3253868
2: Trt2 25.58742 0.4162551
3: Trt3 26.52114 0.8591633
4: Trt4 26.57273 0.1659219
5: Trt5 25.52667 0.8999173
```

Site 2 Result:

```
Plot mean and SD, East River:
   Plot  Trt  Rep    yield       sd
 1:  101 Trt1 Rep1 30.29385 5.696836
 2:  102 Trt2 Rep1 22.46957 3.626253
 3:  103 Trt3 Rep1 30.14270 3.307562
 4:  104 Trt4 Rep1 28.90560 2.683639
 5:  105 Trt5 Rep1 26.30529 2.530336
 6:  106 Trt2 Rep2 28.95949 2.869159
 7:  107 Trt4 Rep2 28.21469 3.085085
 8:  108 Trt5 Rep2 29.31117 2.852946
 9:  109 Trt1 Rep2 28.60462 2.779835
10:  110 Trt3 Rep2 26.33353 3.542929
11:  111 Trt5 Rep3 25.20661 2.503617
12:  112 Trt1 Rep3 25.12032 2.947144
13:  113 Trt2 Rep3 21.75317 3.985475
14:  114 Trt3 Rep3 25.75033 3.065373
15:115 Trt4 Rep3 23.99183 3.969715
16:
ANOVA Site 2:

            Df Sum Sq Mean Sq F value Pr(>F)
Trt          4  23.04   5.761   1.282 0.3535
Rep          2  44.04  22.022   4.899 0.0408 *
Residuals    8  35.96   4.495
```

```
Site 2  Treatment mean and SD
    Trt    yield       sd
1: Trt1 28.00627 2.638161
2: Trt2 24.39408 3.969958
3: Trt3 27.40885 2.385468
4: Trt4 27.03738 2.660044
5: Trt5 26.94102 2.124847
```

Site 1 Result:

Site 1. plot mean and SD:

```
    Plot  Trt  Rep    yield       sd
 1:  101 Trt1 Rep1 23.75406 4.113774
 2:  102 Trt2 Rep1 21.10722 4.767382
 3:  103 Trt3 Rep1 18.69676 3.257502
 4:  104 Trt4 Rep1 23.83555 2.807429
 5:  105 Trt5 Rep1 22.53301 2.420422
 6:  106 Trt2 Rep2 24.96786 3.691423
 7:  107 Trt4 Rep2 22.57880 2.716076
 8:  108 Trt5 Rep2 26.51780 2.967602
 9:  109 Trt1 Rep2 22.83703 1.561861
10:  110 Trt3 Rep2 22.59148 4.064480
11:  111 Trt5 Rep3 22.62228 4.568262
12:  112 Trt1 Rep3 17.12392 6.148994
13:  113 Trt2 Rep3 17.76396 5.326466
14:  114 Trt3 Rep3 24.05672 5.083535
15:  115 Trt4 Rep3 20.93596 3.609412
```

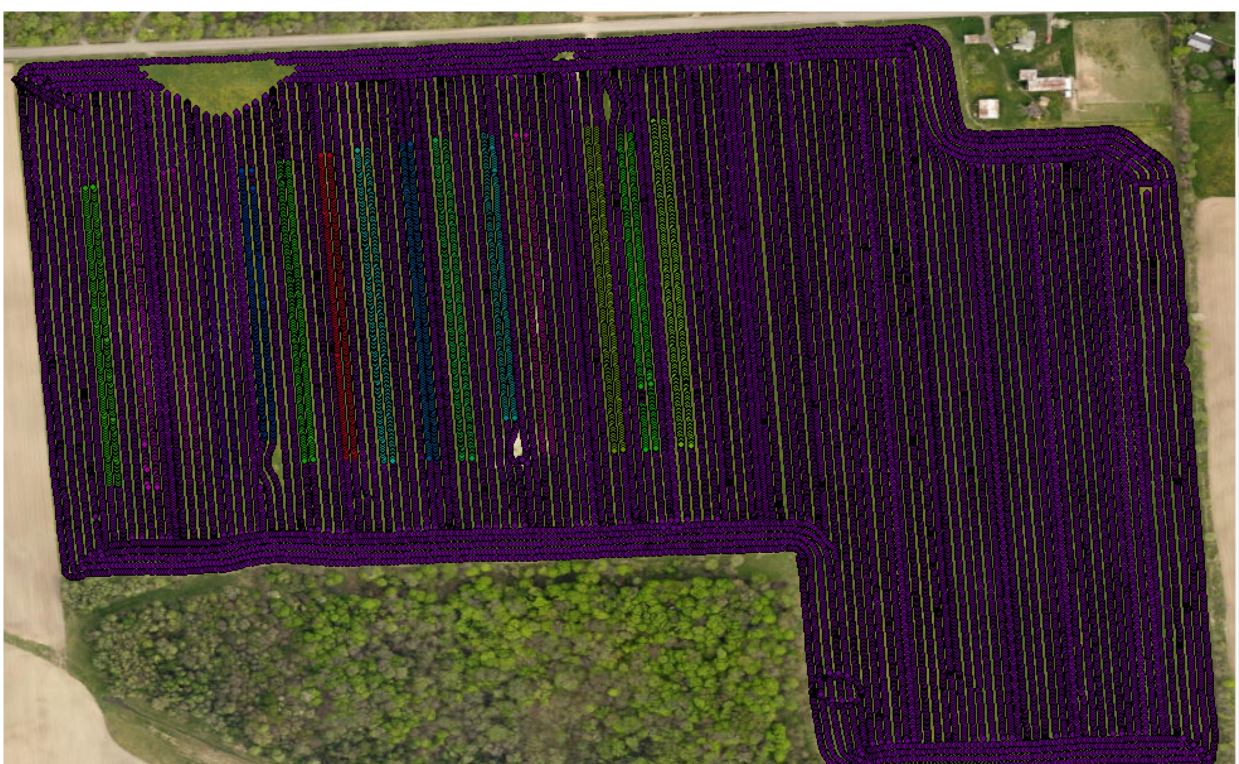
ANOVA Site 1:

```
            Df Sum Sq Mean Sq F value Pr(>F)
Trt          4  14.53   3.632   0.551  0.704
Rep          2  29.02  14.510   2.202  0.173
Residuals    8  52.72   6.590
```

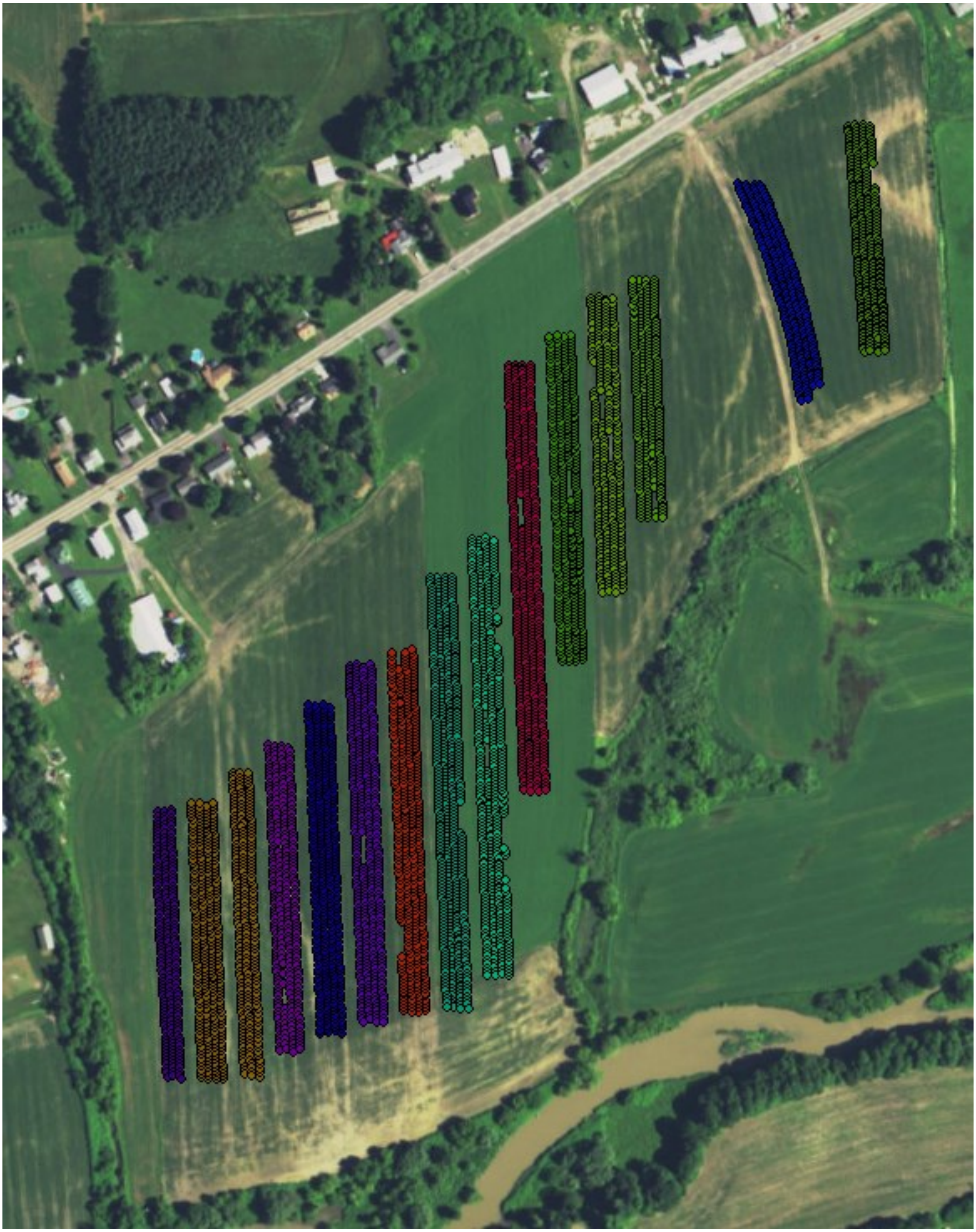
Site 1 Treatment mean and SD:

```
    Trt    yield       sd
1: Trt1 21.23834 3.592572
2: Trt2 21.27968 3.605048
3: Trt3 21.78165 2.770224
4: Trt4 22.45010 1.454068
5: Trt5 23.89103 2.275288
```

Site 1.

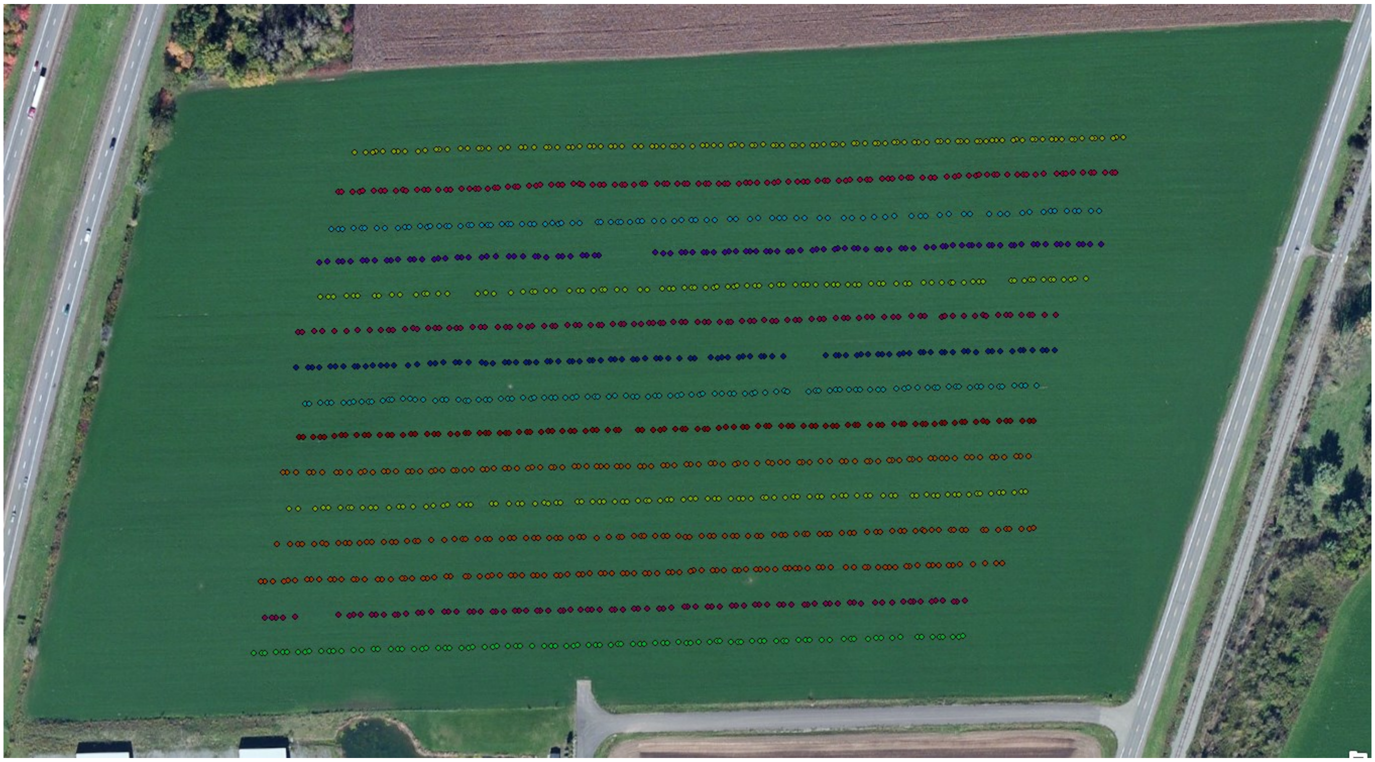


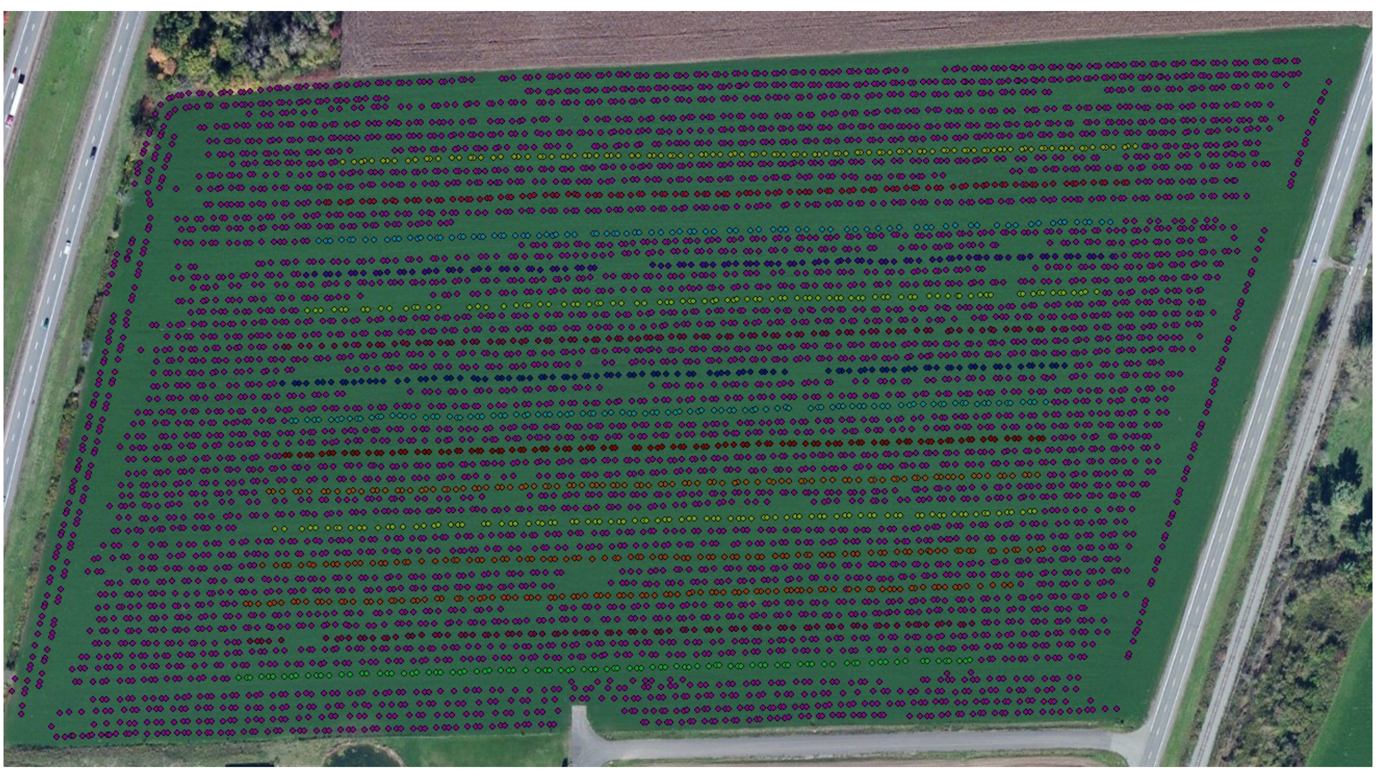
Site 2.



Site 2. Trial strips superimposed on yield monitor data

Site 3.





APPENDIX IV. ANOVA RESULTS FOR TREATMENTS and YIELD

Analysis of Variance (ANOVA) Results testing the effect of fungicide treatments on yield area are shown below.

If we analyze each site independently to look at treatment effects. The results of the ANOVA that none of the treatments had a significant impact on yield. The results for each site follow.

Site 1:

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	14.529387	3.63235	0.4444
Error	10	81.736645	8.17366	Prob > F
C. Total	14	96.266032		0.7743

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Treatment	4	4	14.529387	0.4444	0.7743

Site 2:

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	23.04435	5.76109	0.7201
Error	10	80.00342	8.00034	Prob > F
C. Total	14	103.04778		0.5975

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Treatment	4	4	23.044352	0.7201	0.5975

Site 3:

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	3.1980569	0.799514	2.1554
Error	10	3.7093766	0.370938	Prob > F
C. Total	14	6.9074335		0.1480

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Treatment	4	4	3.1980569	2.1554	0.1480

Site 4:

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	3.273417	0.81835	0.3957
Error	10	20.681318	2.06813	Prob > F
C. Total	14	23.954735		0.8074

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Treatment	4	4	3.2734171	0.3957	0.8074

When all sites are analyzed together as a randomized complete block the ANOVA results show that the model is significant or the method used is appropriate for testing for differences. The results found that site yields were significantly different from each other. In this experiment we did not measure statistically significant yield differences based on treatments. The ANOVA results are shown below.

All Sites Together:

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	324.68317	46.3833	11.2086
Error	52	215.18579	4.1382	Prob > F
C. Total	59	539.86896		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Site	3	3	309.69299	24.9459	<.0001*
Treatment	4	4	14.99019	0.9056	0.4676