THE EFFECTS OF FUNGICIDE APPLIED AT V5/V6, V12, AND VT/R1 ON CORN YIELD IN NEW YORK

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Abstract

Fungicides are used to manage diseases in a crop. They limit infection and disease development and thus prevent or minimize yield loss. Disease development is dependent on weather conditions that occur during the growing season. In New York, certain diseases occur every year under the right environmental conditions, for example, northern corn leaf blight and gray leaf spot. A study that compared applications of fungicide made at different growth stages was done in the Finger Lakes Region of Upstate New York in 2018 to evaluate the effect of fungicide on disease and yield.

A plot was established on Lott Farms LLC in Waterloo, New York that was planted to a BMR silage corn and a Pioneer field corn, which each have resistance to diseases prevalent in the area. The plot was set up so that Mycogen F2F379 and Pioneer 9998AMXT each had three replications of hybrids either treated with a fungicide at V5/V6, V12, VT/R1, or with no fungicide application.

Disease assessments on the plot were made throughout the growing season. Assessments for disease was done every two weeks by looking at the canopy of 20-30 plants within each 8 row strip and recording if disease was observed. Disease was not observed within the plot until October 9, 2018. Standability was assessed by observing lodging at harvest. Yield data from each treatment was also collected. Climate Fieldview was used throughout the growing season to monitor the health of the crop through looking at the field health maps to make note of other environmental stresses. These health maps are NDVI (Normalized Difference Vegetation Index) imagery of the

field and measure the health of the vegetation. The maps were used weekly to compare the health of the field from one week to the next. Precipitation at the plot location was monitored throughout the growing season using the precipitation element within the Fieldview Climate app.

Disease severity within the plot did not differ among all four of the fungicide treatments. Within the plot Gibberella ear rot was observed in the plot during the 2018 growing season. Gibberella ear rot was first observed at R5 growth stage. No difference in the amount of Gibberella ear rot was observed between the hybrids. More green leaves were seen in P9998 AMXT sprayed with a fungicide at VT/R1 growth stage than the same hybrid in different fungicide treatments, and F2F379. Lodging at harvest was more severe in F2F379 than P9998 AMXT which had no lodging. Less lodging was seen in F2F379 in the V5/V6 and VT/R1 fungicide treatment blocks compared to the no fungicide and V12 fungicide treatments. The yield of P9998 AMXT was greater than that of F2F379.

To better determine if fungicides contribute to improved plant health and greater yields, more testing needs to be done.

Introduction

Agriculture is a diverse and complex enterprise. Farmers have to consider many management variables to grow the best possible crop. Weather is a huge factor that cannot be controlled. Weather influences crop disease development. Depending on the climate, diseases may flourish or occur at barely detectable levels. Farmers may need to scout more often for insect and disease pressure. Also, farmers need to select hybrids adapted for each acre to ensure the seed gets the best start possible.

Corn is a vital crop in the United States. There are approximately 1,150,000 acres of corn annually planted in New York, and it is the 17th leading state in the United States in corn acres (Crops, ACF, 2014). According to the USDA (United States Department of Agriculture) in 2018, 615,000 acres of field/grain (97,785,000 bushels) and 445,000 acres (8,455,00 tons) of silage corn were harvested in New York (2018 STATE AGRICULTURE OVERVIEW, 2019). The overall average yield for New York State was 159 bushels per acre in field/grain corn and 19 tons per acre for silage corn. Most of the corn in the area is used for ethanol or for feed (2018 STATE AGRICULTURE OVERVIEW, 2019).

New York State is different from Midwestern and Southern States, where fungal diseases are more common (Mueller, Wise, and Sisson, 2018). In Upstate New York, fungal diseases such as common rust, northern leaf blight, eyespot disease, gray leaf spot, and Fusarium ear rot occur. The severity of disease incidence depends on weather conditions. Fungal diseases, if they occur, are seen later in the season at growth stage R2 and application of a fungicide at this time may be too late to reduce disease. Disease will only develop if the right host is in the field is susceptible to a pathogen, if the pathogen is present in the field and there are the right environmental conditions (Fig. 1).

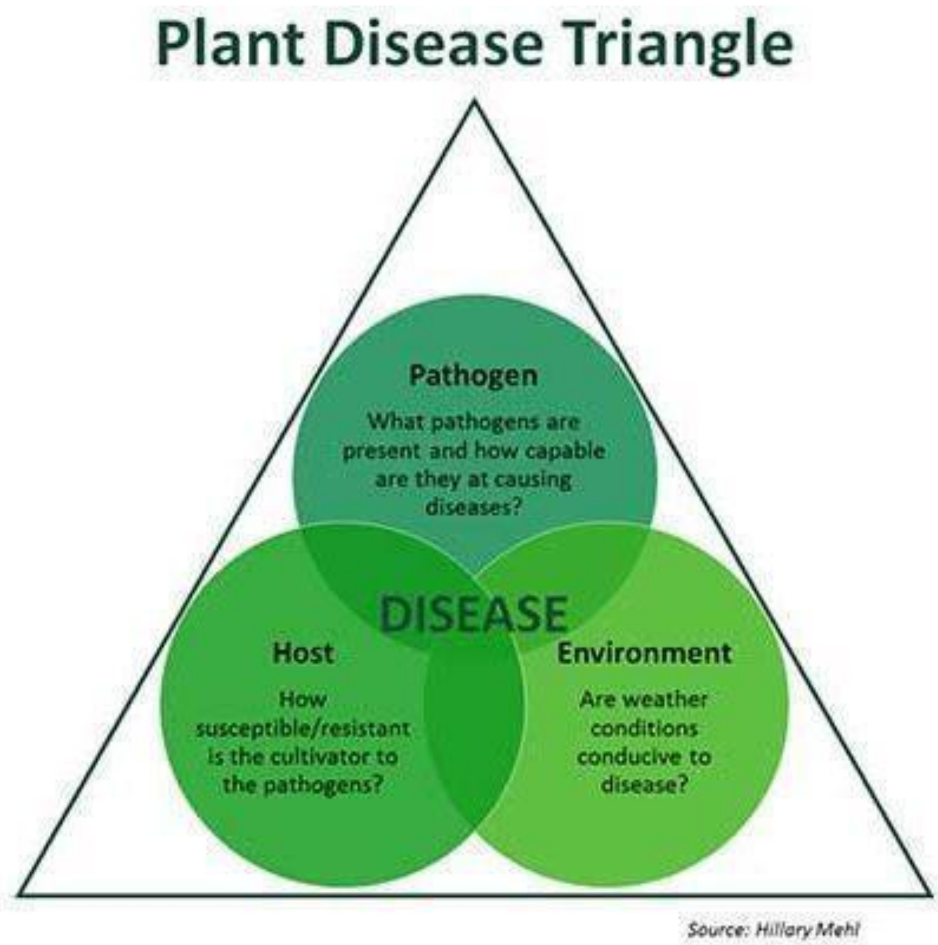


Figure 1: The Disease Triangle shows what the factors that are required for plant disease to occur (Michele, 2019).

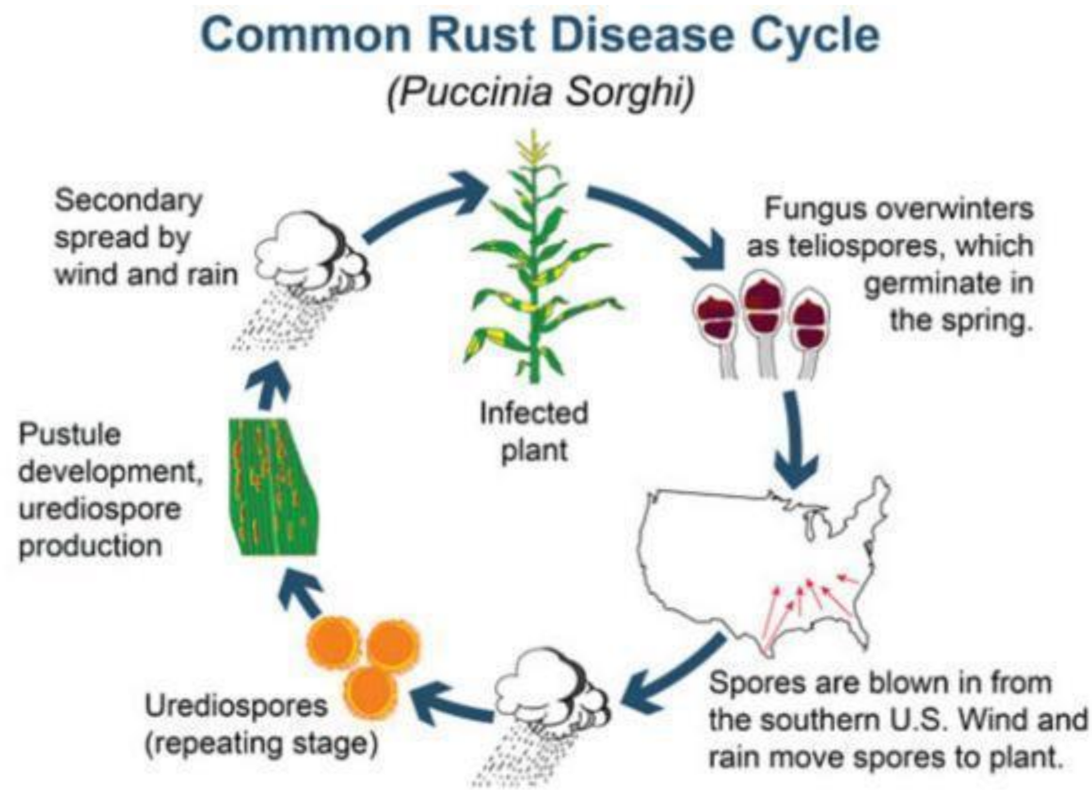


Figure 2: Disease cycle of common rust and how it can develop under the right conditions (Pioneer, 2019).

Weather impacts a crop in many ways, including moisture, drought, as well as disseminating insects and pathogens that move in on passing storms. Hail storms can injure the crop resulting in entry points for some pathogens and insects to enter into the plant. Understanding the role the weather plays in crop production can help a farmer ensure that his crop stays healthy and grows to the best of its potential. Monitoring weather history from previous years or looking at the forecast for the next few weeks and taking into consideration the stage of the crop can help with decisions to apply a fungicide.

Management actions for fungal diseases may need to be considered if disease pressure is affecting ROI (Return on Investment). A fungicide application could be beneficial for farmers to look into should a situation develop where they need to take action. A fungicide is a chemical that protects the plant from infection from pathogens and therefore helps keep the plant healthy. Disease happens when you have infection and colonization of the leaf tissue. Fungicides kill fungi, fungal spores, and protect against infections. Fungicides kill by damaging cell membranes, inactivating critical enzymes or proteins, and interfering with key metabolic processes like respiration. Therefore applying a fungicide protects the crop from infection by pathogens that can cause disease and also should protect the yield of the corn crop.

Determining if fungicides need to be applied on corn crops in New York needs to be evaluated to provide farmers with information to determine for themselves if this practice is something that they should integrate into their crop production program. As well as if the cost of doing the application is economically feasible.

The creative component research specifically investigated Headline AMP®, a fungicide currently being recommended to farmers in New York State. Headline AMP contains the active ingredients pyraclostrobin and metconazole that have different modes of actions. Metconazole belongs to FRAC Group 3, and pyraclostrobin belongs to FRAC Group 11(CDMS-Headline AMP). The mode of action for Pyraclostrobin is that it belongs to the group of respiration inhibitors (CDMS-Headline AMP). Metconazole mode of action is that it inhibits demethylation of sterol biosynthesis which disrupts the cell membrane synthesis of the target site (CDMS-Headline AMP). The manufacturer (BASF) recommends using Headline AMP in fields that are corn on corn, no-till, or minimum-till conditions (Headline AMP® Fungicide, 2019). This is because corn pathogens are more likely to overwinter in crop residue and thus be a source of inoculum for disease to reoccur year after year if rotation or tillage are not used to break the disease cycle. In Fig 2 a disease cycle is demonstrated on how the process looks from start to finish and how a corn crop can be affected, and shows farmers why their production practices and rotation of crops is vital to the health of their operation. The best time to apply Headline AMP is at tassel to help control the diseases that occur later in the season so that the corn can utilize its resources in filling grain and not fighting disease (Headline AMP® Fungicide, 2019).

Numerous studies have evaluated the effect of fungicides on corn. Wise (2019) reported that, with high disease pressure, it was well worth applying a fungicide to protect yield. Similarly, Flanary and Crawford (2014) evaluated one fungicide on four corn varieties over three years and found no difference in yield compared to the no fungicide applied check. They suggested there was a small window of opportunity to see benefits in yield from applying fungicide and an application decision should be made only when disease pressure was high enough. Therefore, if one was to ask when not having disease pressure until harvest time after the crop has gone through all its growth stages would it have been beneficial for the plant or cost effective to apply the fungicide? It can be determined that if enough factors are present in a field such as extended humid weather, corn on corn, no-till practices, previous disease pressure, and poor hybrid ratings then a fungicide can be a great preventative tool.

In New York State corn can be grown for either grain or silage production. Grain corn or field corn is used for animal feed, ethanol production, and in many other by products. For example, sweetener in soft drinks, taco shells, corn flour, corn starch, corn syrup and many more. Silage corn or brown midrib (BMR) corn is primarily used for feed for dairy cows as it results in higher fiber digestibility. The BMR hybrids are usually more susceptible to diseases than field corn. In addition, BMR corn is also more susceptible to lodging than field corn and thus has poorer standability that can affect harvest and therefore yield. Lodging occurs when the stalk breaks and falls over resulting in yield loss over time. Reasons for lodging include severe weather, such as heavy rain fall with strong winds or hail. European corn borer can enter and damage stalks resulting in ear drop or lodging. Stalk rot, caused by anthracnose, weakens the stalk tissues and can result in lodging (Nielsen and Colville, 1914). Minimizing lodging in BMR corn is important to silage farmers. Thus a farmer needs to take into consideration the hybrid and its characteristics e.g., yield, disease rating, insect rating, digestibility, maturity, etc. since they are important for successful crop production.

Fieldview/Climate is used either through an app or web-based program and is a way for farmers to analyze field data from multiple years to improve production while still staying sustainable and keeping the environment safe. Fieldview allows farmers to see the health of their crops throughout the growing season via satellite through NDVI imagery. Fieldview gives the farmers a picture of their field taken from a satellite to show them vegetative health within the field every week. Fieldview helps connect farmers to different layers of information including field health maps that help identify issues early to prioritize scouting; vegetation maps help monitor biomass over time and true color images that provide a real-world view of fields. The app also provides weather data for individual fields. Fieldview sends health maps of each field to the grower every weeks that allows the farmer to monitor what is occurring in each field in addition to in field regular scouting.

The following research was done to document the effect of fungicide application on the health of the corn, standability, and yield. The objectives were to compare fungicide application timing on the yield response of two corn varieties, a BMR corn and a field corn.

Materials and Methods

We conducted a field experiment in 2018 at Lott Farms LLC in Waterloo, NY, to determine the effect of an application of fungicide on two varieties of corn at three growth stages. The BMR variety was a Mycogen F2F379 and the grain corn hybrid was a Pioneer P9998 AMXT. Mycogen F2F379 is a medium to tall plant and with a full canopy. Mycogen seeds do not score their hybrids for disease resistance. Disease tolerance information for northern leaf blight is “manage appropriately.” No information is given for gray leaf spot, anthracnose stalk rot, or Gibberella ear rot. Mycogen provides information for fungicide response, as “high” for F2F379. Pioneer P9998 AMXT is a high yielding early season variety with exceptional root strength and moderate plant height. Pioneer rates hybrid disease resistance on a 1-9 scale. Where 1-3 is susceptible, 4-5 is moderately resistant, 6-7 resistant, and 8-9 highly resistant. P9998 AMXT was rated 5 for northern leaf blight, 4 for gray leaf spot, and 4 for Gibberella ear rot. No rating was given for anthracnose stalk rot (Corn Seed Guide, 2018).

The corn was planted in a no-till cropping system with a winter cereal rye cover crop that was terminated with Roundup WeatherMax at 32 oz, Tripleflex II at 2.5 pt. and Request at 1.5 qt. five days after the corn was planted. The field has been in a corn, soybean, and wheat rotation for the last 22 years. The experiment was approximately

9.5 acres and had a soil type of Angola Silt Loam. Angola Silt Loam is a dark grayish brown and olive brown shaly clay loam to shaly silty clay loam (Hutton, 1972). It is usually poorly drained soil however drainage tile has been installed in the field.

The plot was planted on May 21, 2018 at a planting population of 36,000 plants per acre for both hybrids. Mycogen seed recommends that F2F379 does well planted at either a low or high population. Pioneer seed recommends that the farmer should consult with a local seed representative for the best population for the given area. Lott Farms plants all their corn at a 36,000 population due to, this is the standard practice in the area. Each hybrid was planted in strips eight rows wide and varied between 715 to 906 feet long due to the shape of the field.

Table 1: Layout of the length of each of the strips within the plot.

	Length per Strip (ft.)
F2F379- No Fungicide	903
P9998 AMXT- No Fungicide	907
P9998 AMXT- No Fungicide	906
F2F379- No Fungicide	902
F2F379- No Fungicide	897
P9998 AMXT- No Fungicide	833
P9998 AMXT- V5/V6	867
F2F379- V5/V6	850
F2F379- V5/V6	820
P9998 AMXT- V5/V6	804
P9998 AMXT- V5/V6	790
F2F379- V5/V6	772
F2F379- V12	760
P9998 AMXT- V12	756
P9998 AMXT- V12	744
F2F379- V12	741
F2F379- V12	734
P9998 AMXT- V12	729
P9998 AMXT- VT/R1	725
F2F379- VT/R1	721
F2F379- VT/R1	719
P9998 AMXT- VT/R1	717
P9998 AMXT- VT/R1	716
F2F379- VT/R1	715

Liquid starter fertilizer 9.5-20-6.5 (35 gallons per acre) was applied at planting. Five weeks after planting a split application of 30-00-00-2S (35 gallons per acre) which consists of 32% UAN (Urea Ammonium Nitrate) with Ammonium Thiosulfate was applied with a 4030 John Deere Self-propelled sprayer with 360 Y-drops. Plots were treated with a fungicide, Headline AMP (pyraclostrobin and metconazole; 14 ounces per acre) in 15 gallons of water per acre as a carrier at either (i) growth stage V5/V6 (ii) V12 or (iii) VT/R1 using a 4730 John Deere self-propelled sprayer. Table 2, 3 and Figure 3 show the plot layout of the corn hybrids planted and the growth stages at which the fungicide was applied.

Corn crop growth stages are divided into either V for vegetative stages or R for reproductive stages. The field experiment looks at three specific growth stages. Growth stage V5/V6 is defined as 5 or 6 leaves with visible collars respectively. At this growth stage the primary ear and tassel are initiated and kernel row numbers are determined. At V12 (12 leaf fully extended with collar visible) the potential number of kernels and ear size is determined. At VT/R1, tasselling occurs and silking begins, respectively.

Table 2: Layout of treatments within the plot for corn hybrids and fungicide timing of applications.

F2F379- No Fungicide	EXPERIMENT-1
P9998 AMXT- No Fungicide	
P9998 AMXT- No Fungicide	
F2F379- No Fungicide	
F2F379- No Fungicide	
P9998 AMXT- No Fungicide	
P9998 AMXT- V5/V6	EXPERIMENT-2
F2F379- V5/V6	
F2F379- V5/V6	
P9998 AMXT- V5/V6	
P9998 AMXT- V5/V6	
F2F379- V5/V6	
F2F379- V12	EXPERIMENT-3
P9998 AMXT- V12	
P9998 AMXT- V12	
F2F379- V12	
F2F379- V12	
P9998 AMXT- V12	
P9998 AMXT- VT/R1	EXPERIMENT-4
F2F379- VT/R1	
F2F379- VT/R1	
P9998 AMXT- VT/R1	
P9998 AMXT- VT/R1	
F2F379- VT/R1	

Table 3: Treatment replications within the plot for corn hybrid, type of corn and timing of fungicide application.

Replications within the plot			
Replications	**Corn hybrid**	**Type of Corn**	**Fungicide application Timing**
1	Mycogen F2F379	BMR Silage	No Fungicide
2	Mycogen F2F379	BMR Silage	No Fungicide
3	Mycogen F2F379	BMR Silage	No Fungicide
1	Pioneer 9998AMXT	Field Corn	No Fungicide
2	Pioneer 9998AMXT	Field Corn	No Fungicide
3	Pioneer 9998AMXT	Field Corn	No Fungicide
1	Mycogen F2F379	BMR Silage	V5/V6
2	Mycogen F2F379	BMR Silage	V5/V6
3	Mycogen F2F379	BMR Silage	V5/V6
1	Pioneer 9998AMXT	Field Corn	V5/V6
2	Pioneer 9998AMXT	Field Corn	V5/V6
3	Pioneer 9998AMXT	Field Corn	V5/V6
1	Mycogen F2F379	BMR Silage	V12
2	Mycogen F2F379	BMR Silage	V12
3	Mycogen F2F379	BMR Silage	V12
1	Pioneer 9998AMXT	Field Corn	V12
2	Pioneer 9998AMXT	Field Corn	V12
3	Pioneer 9998AMXT	Field Corn	V12
1	Mycogen F2F379	BMR Silage	VT/R1
2	Mycogen F2F379	BMR Silage	VT/R1
3	Mycogen F2F379	BMR Silage	VT/R1
1	Pioneer 9998AMXT	Field Corn	VT/R1
2	Pioneer 9998AMXT	Field Corn	VT/R1
3	Pioneer 9998AMXT	Field Corn	VT/R1

Figure 3: Layout of the plot from Fieldview Climate. Treatment 1 starts at the top of the field. Blue represents the FSF379 and purple represents the P9998AMXT (The Climate Corporation, 2019).

Precipitation data that occurred throughout the growing season was captured from Fieldview Climate. The precipitation was entered into Microsoft Excel making tables and creating a graph with the data. Fieldview Climate emailed field health reports every week throughout the growing season and were looked at to know plant health. In addition, assessments of plant health were made throughout the growing season by in field assessment. Foliar disease was assessed weekly in each of the treatment strip starting at V4 through harvest. Foliar disease was measured on a scale from 0 to 10, 10 being that there was foliar disease on all leaves of the corn plant. The health of the plant was assessed using the push test as well as the pinch test. In each strip, 20 to 30 corn plants were chosen randomly and the “push test” and “pinch test” was used to evaluate stalk health. For the “push test”, the stalk was pushed 30° from the vertical and plants that broke were recorded as lodged (Jackson-Ziems, 2014). For the “pinch test”, the lowest node possible on the stalk above the brace roots was squeezed between the thumb and forefinger (Jackson-Ziems, 2014). If the stalk collapsed, the plant was recorded as having stalk rot. Ear disease was assessed by pulling back the husks and examining the ear for disease. Notes were taken on whether disease was absent or present, if present, notes were taken using a scale from 0 to 10, 10 indicating that the entire ear was covered in a disease, what disease, and where on the corn plant it was found. When Gibberella ear rot was observed, within each 8 row strip at random 17.5 feet would be measured out which equals 1/1,000 of an acre to determine the amount of Gibberella ear rot present. Lodging throughout each treatment strip was estimated visually at harvest on a scale from 1 to 10, with 10 = 100% lodging.

The plot was harvested on November 9, 2018 with a John Deere S660 combine. Each of the strips of the test plot were harvested individually and unloaded into a grain cart that was equipped with a scale on it allowing to observe the weight for each of the strips. As each individual strip was harvested a gallon size Ziploc bag was used to obtain a sample of grain from each test strip. Those samples were then taken back to the main farm where a Dickey John GAC2100 Moisture Tester that is calibrated annually was used to measure grain moisture and test weight.

Data from the research plot was analyzed using a spreadsheet, Microsoft Excel. Rainfall, disease, green leaves, standability, and yield results from each of these categories were entered into the spreadsheet. Using Microsoft Excel, mean, standard deviation, and the ANOVA table was used to produce the P-values that were calculated and then placed into tables or graphs produced through Excel. The ANOVA tables compared the two hybrids per treatment of either no fungicide application or fungicide application at the three different growth stage timings.

Results and Discussion

By looking at the weather that occurred during the growing season of the research we are able to distinguish patterns that possibly could determine if fungicide should or should not be used based upon yield results and the health of the plant.

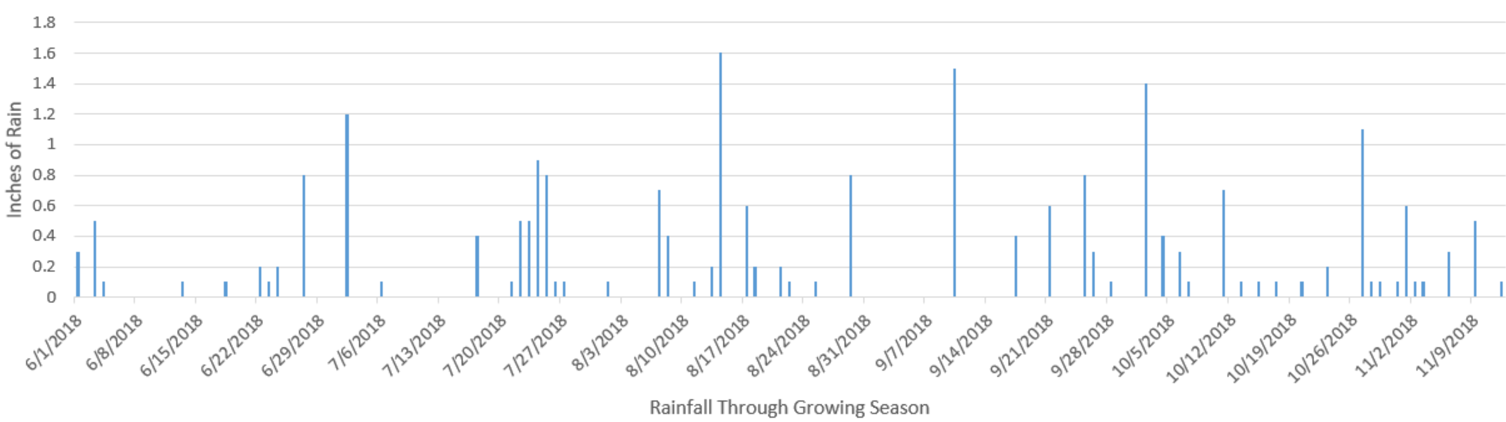


Figure 4: Daily precipitation from planting (1 June 2019) through harvest (15 November 2020) at the Lott Farms, NY.

Rainfall in Seneca County, where Lott Farms LLC is located, from January 1st through December 31st, 2018 was 38.5 inches (US Department of Commerce, and NOAA, 2018). On average Seneca County receives about 36 inches of rain in a year (US Department of Commerce, and NOAA, 2018). From the planting date of May 21, 2018 to the harvest date November 9, 2018 22.5 inches of rain was recorded. Harvest was delayed several weeks due to snow and rain that made field conditions impossible for harvest.

No foliar diseases developed in either hybrid through the growing season, until on October 9, 2018, Gibberella ear rot (Fig 5 and 6) was observed in the plot (Table 4).

Table 4: Mean Gibberella ear rot on 9 October 2019 in two hybrids that were sprayed with Headline Amp at different growth stages. The ear rot was assessed on a scale of 1-10 with 10 = being the entire strip had Gibberella ear rot on every single ear.

	Headline AMPa application timing			
	No Fungicide	V5/V6[b]	V12	VT/R1
F2F379	7.3	7.1	6.9	7.1
P9998 AMXT	7.5	7.4	7.4	7.5
P-Value	0.674615	0.562378	0.339996	0.459431

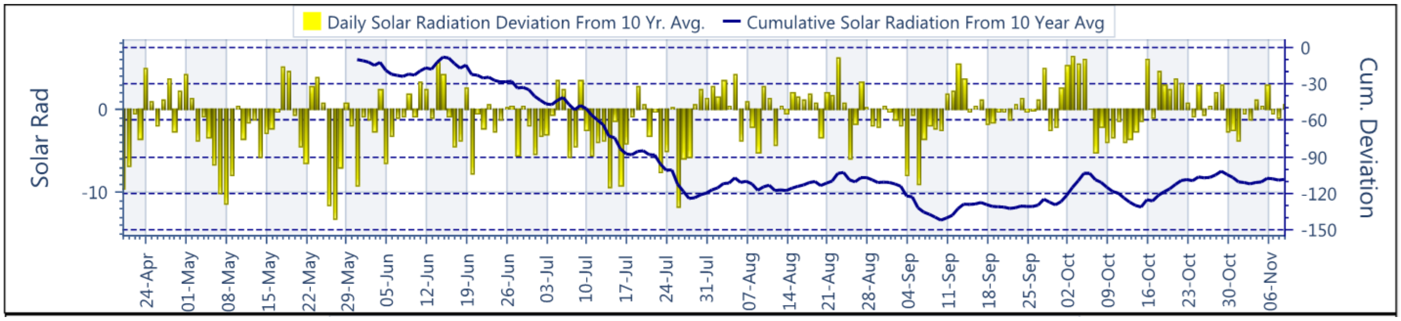
[a] Headline AMP (Pyraclostrobin + metconazole) applied at 10 fl. oz/acre in 15 gallons of water.
[b] Growth stages of corn where V5/V6 = 5th or 6th collar visible, V12= 12th collar visible, VT/R1= Tassel and Silking visible.

Gibberella ear rot was detected throughout the field, however there was no difference in the amount of ear rot between both hybrids (P>0.05) whether a fungicide was applied or not. Headline AMP is not labelled for Gibberella ear rot management (CDMS-Headline AMP, 2018). After harvest was completed at Lott Farms, corn including the corn in the plot started being delivered to their local ethanol plant where it was rejected for high levels of vomitoxin (deoxynivalenol).

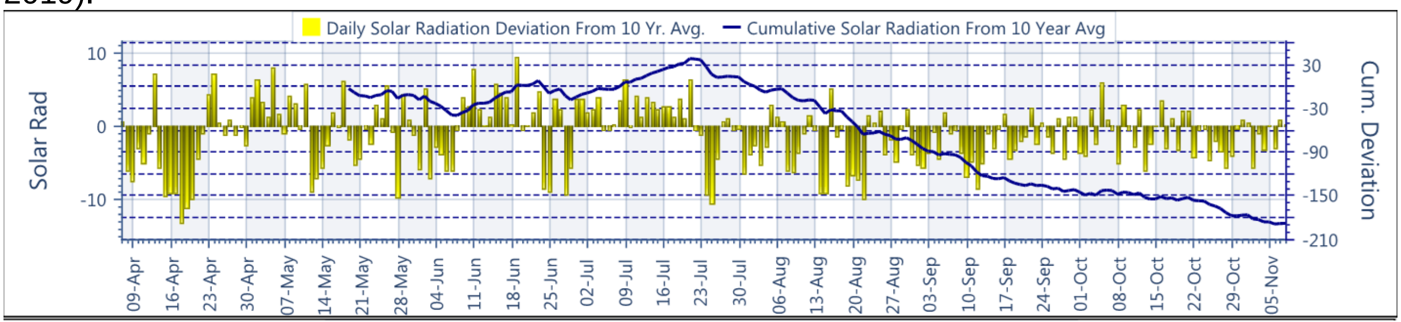
Figure 5 & 6: Gibberella ear rot on a nearby farm that had no fungicide application in Finger Lakes Region (Stanyard, 2018).

Gibberella ear rot is caused by the fungus *Fusarium graminearum* (Willyerd, 2016). This fungus usually infects through the silks on the ear. Infection results in a pinkish-white mold developing at the tip of the ear. Cool, wet weather, or humidity during silking and wet conditions at harvest favor the development of Gibberella ear rot in corn. Gibberella ear rot is caused by the fungus *Fusarium graminearum* (Willyerd, 2016). This fungus usually infects through the silks on the ear. Infection results in a pinkish-white mold developing at the tip of the ear. Apart from affecting grain quality (moldy), grain may also be contaminated with mycotoxin's, the most common being deoxynivalenol. This mycotoxin is harmful to both humans and animals, therefore the marketing of the grain can become very difficult. Gibberella ear rot impacted the entire Finger Lakes region in 2018. Many farmers did not know their grain was contaminated until after taking the grain to the mills where many loads of corn were rejected. Vomitoxin was not measured in the plot due to not knowing it was there and all corn from Lott Farms goes into storage in four, forty thousand bushel bins and is co-mingled. This scenario of the Gibberella ear rot highlights the true importance of scouting. If fields had been scouted for ear rot prior to harvest and observed, farmers may have been alerted to be aware of potential mycotoxin contamination in their grain and taken action to possibly reduce contamination and co-mingling of grain in storage, e.g. harvesting early, drying and cooling the grain as quickly as possible, and storing grain from fields with moldy ears in separate grain bins to grain harvested from fields where no Gibberella ear rot was observed.

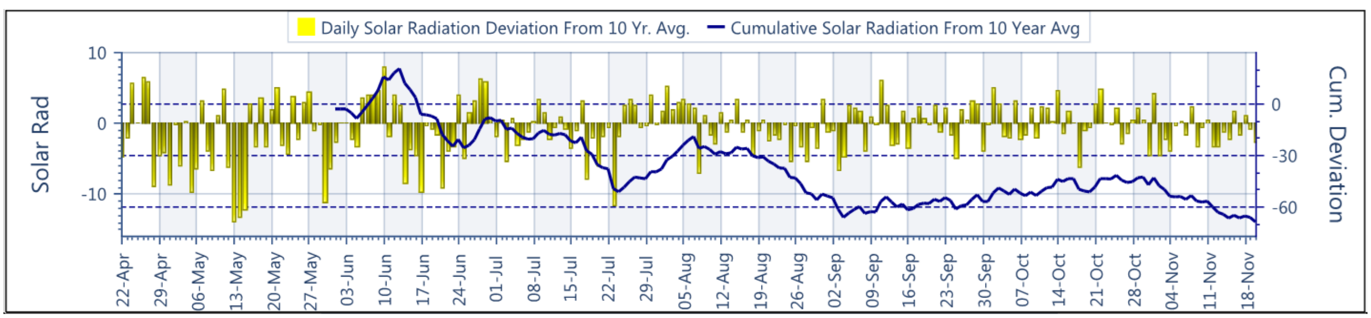
The following graphs are from a Pioneer Test plot approximately 7.2 miles from the Lott Farms LLC research plot. Weather is monitored at this plot including solar radiation from planting through harvest.



Graph 1: Growing Season 2017 Solar Radiation from local Pioneer Test Plot (Gillette, 2019).



Graph 2: Growing Season 2018 Solar Radiation from local Pioneer Test Plot (Gillette, 2019).



Graph 3: Growing Season 2019 Solar Radiation from local Pioneer Test Plot (Gillette, 2019).

Graphs 1, 2, and 3 represent three years 2017, 2018, and 2019 and show the difference in the solar radiation among the years. Graph 2 depicts solar radiation during the time of the research at Lott Farms LLC was conducted. The graph shows there was hardly any solar radiation from the middle of July through November. In comparison, Graph 1 and 3, for 2017 and 2019, respectively, show there was more solar radiation during this same period in each year. Therefore, the lower the solar radiation may have contributed to an environment that favored the ear mold development and mycotoxin contamination in the Fingerlakes region (Gillette, 2019).

Table 5: Mean Green leaves of two hybrids of corn that Headline Amp was applied to at three growth stages. Green leaves were scored by visually estimating the green leaves within each treatment strip at harvest where 0 = no green leaves and 10 = 100% green leaves.

	Headline AMP[a] application timing			
	No Fungicide	V5/V6[b]	V12	VT/R1
F2F379	0	0	0	0
P9998 AMXT	0	0	5	7.3
P-Value			0.117881	0.0000253

[a] Headline AMP (Pyraclostrobin + metconazole) applied at 10 fl. oz/acre in 15 gallons of water.
[b] Growth stages of corn where V5/V6 = 5th or 6th collar visible, V12= 12th collar visible, VT/R1= Tassel and Silking visible.

In the strips that were not sprayed with a fungicide and the strips that were treated with a fungicide at V5/V6, no green leaves were seen in either hybrid. In the strips sprayed at V12, some of the canopy of P9998 AMXT was still green but this was not different to the canopy of F2F379 (P=0.117881). In the strips that were treated with a fungicide at VT/R1, the canopy of P9998 AMXT had significantly more green leaves than the canopy of F2F379 that had no green leaves (P=0.0000253). Although I cannot statistically compare the strips treated at VT/R1 to the other treatment strips in my trial because of the experimental design, the fact that the VT/R1 strips of P9998 AMXT were greener than strips planted to the same hybrid but sprayed with a fungicide at a different time suggests that the fungicide application at VT/R1 may have kept the canopy of P9998 AMXT greener. Farmers who apply fungicides to their crops often observe that those crops appear to stay greener longer than crops not sprayed with a fungicide. Byamukama et al (2013) reported a fungicide application at VT/R1 delayed senescence of the corn canopy. The difference in the green leaves between the two hybrids was likely due to genetics since F2F379 is a silage hybrid and P9998 AMXT is a grain hybrid.

Figure 7: P9998 AMXT was still green at the time of harvest compared to the F2F379 variety (Lott, 2018).

Table 6: Standability of two hybrids of corn that a Headline Amp was applied to at three growth stages. Standability was scored by visually estimating the lodging within each treatment strip at harvest where 0 = no lodging and 10 = 100% lodging.

	Headline AMP[a] application timing			
	No Fungicide	V5/V6[b]	V12	VT/R1
F2F379	8.3	4	7	4
P9998 AMXT	0	0	0	0
P-Value	0.0000152	0.116117	0.002192	0.01613

[a] Headline AMP (Pyraclostrobin + metconazole) applied at 10 fl. oz/acre in 15 gallons of water.
[b] Growth stages of corn where V5/V6 = 5th or 6th collar visible, V12= 12th collar visible, VT/R1= Tassel and Silking visible.

No evidence of stalk rot was detected in either hybrid using the pinch and pull tests. At harvest, no lodging was observed in P9998 AMXT (Table 6), and lodging was observed in F2F379. The greatest amount of lodging (reduced standability) was observed in the strips of F2F379 that were not treated with a fungicide and the strips to which Headline AMP was applied at V12. Less lodging occurred in strips of F2F379 that were sprayed with Headline AMP at V5/V6 and VT/R1. This suggests that application of a fungicide at V5/V6 and VT/R1 may improve standability, however more research is needed to prove this since the experimental design used in this study does not allow me to compare standability amongst fungicide timings. Recently Robertson et al (2020) reported an application of fungicide at VT/R1 improved standability in corn.

Table 7: Mean yield of Mycogen F2F379 and Pioneer 9998AMXT, at different application timings of Headline Amp in Seneca County, in New York State in 2018.

	Headline AMP[a] application timing			
	No Fungicide	V5/V6[b]	V12	VT/R1
F2F379	142	136	148	148
P9998 AMXT	185	180	180	184
P-Value	0.002161	0.000064	0.003158	0.000058

[a] Headline AMP (Pyraclostrobin + metconazole) applied at 10 fl. oz/acre in 15 gallons of water.
[b] Growth stages of corn where V5/V6 = 5th or 6th collar visible, V12= 12th collar visible, VT/R1= Tassel and Silking visible.

Yield differed between the Mycogen and Pioneer varieties. Pioneer 9998AMXT consistently out yielded Mycogen F2F379 ($P<0.05$). This was not surprising since F2F379 is a silage corn, however in this plot it was grown as a grain crop. The P9998 AMXT no fungicide treatment out yielded the applications of fungicide treatments done at the specific growth stages, although a statistical comparison between fungicide application timings cannot be done due to the experimental design used in this study.

The goal of this study was to compare the effect of different fungicide application timings on disease, green leaf area, standability and yield of corn. Due to the experimental layout in the trial, I was unable to answer the question I had. The reason for the layout of the 2018 plot at Lott Farms was due to the equipment size that was available to be used for the plot. A 120 foot sprayer boom was used to apply the fungicide consequently the two hybrids were each planted in 3 strips that were each 20ft wide. Looking back at the research plot the layout of the plot should have been different for the research that was conducted. Rather than each experiment representing a different fungicide application timing, each experiment should have been a different hybrid, and then within each experiment fungicide applied to strips within the experiment at different timings. This proposed experimental design is a split plot design in which the hybrid is the main plot and the fungicide timing the split plot. The plot should have had three experiments containing the two hybrids (main plots). Within those blocks, the fungicide application timing treatments (subplots) should have been randomized. Therefore, each treatment would have had a different soil type, elevation, or been in an area in the field that was wet or dry. By having the layout of the plot in this way, I could have determined the effect of fungicide application timing of plant health and yield.

The cost of applying Headline AMP per acre was $31.83. To be cost effective, there needs to be continuous disease pressure or there needs to be enough of a plant health response in yield to cover the cost of the application. Looking at the data from this test plot that was conducted we conclude that there was a negative ROI because there appeared to be no yield advantage by applying the fungicide. Reasons to consider applying a fungicide should include (i) a field that has consistent disease pressure year after year; (ii) crop rotation, if a field is corn-on- corn for several years; (iii) weather, if hot and dry then there would be no need to apply the fungicide because conditions will not be conducive to disease, therefore monitoring weather patterns is crucial. In addition commodity price should also be considered to determine if it would be cost effective to apply the fungicide. Additionally the yield potential of the field with and without disease to determine if a fungicide application should take place. As well as factoring in the cost of the fungicide and application charge.

Conclusion

From the results that were gathered first looking at disease among the two varieties and the four different treatments of fungicide, fungicide did not protect the corn plant from Gibberella ear rot. Looking at the data that was gathered from the green leaves it appears that applying a fungicide at VT/R1 kept the plant greener, and presumably healthy longer through the critical stages of grain fill when disease can occur. Lodging was seen in all the F2F379 strips and appeared worse when no fungicide applied treatment suggesting a fungicide application may reduce lodging. Lastly, when looking at yield the P9998 AMXT variety yielded the best at No Fungicide application stage. Although some of these results suggest fungicides may help with plant health and yield, due to the experimental design used in the study it is difficult to make clear conclusions about fungicide application timing. Further research will be required to come to this conclusion.

Since very little leaf disease was seen in the trial, there is not enough evidence showing that there is substantial disease pressure through the season to justify applying the fungicide.

I would recommend doing the plot again with a different experimental layout as well as doing the same trial in more locations to have more variability within the research. Also considering other variables such as weather throughout the growing season could help improve our understanding of how fungicides affect plant health and yield of corn.

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