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2019 THE EFFICACY OF SPRAYING ORGANIC FUNGICIDES TO CONTROL FUSARIUM HEAD BLIGHT INFECTION IN SPRING WHEAT

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Locally grown grains, such as wheat and barley, are in high demand in the Northeast for both livestock feed and human consumption. Many bakeries feature loaves baked with locally grown wheat. Hard red spring wheat is most commonly used for bread flour. One major challenge that grain growers encounter is infection by disease-causing fungi, such as the fungus *Fusarium graminearum*, whose spores can infect plants from flowering until grain fill. Fusarium head blight (FHB) can shrivel grain, decrease seed germination, decrease yields, and contaminate grains with mycotoxins. The primary mycotoxin associated with FHB is deoxynivalenol (DON), a vomitoxin. If DON concentrations are above 1 ppm, they may pose health risks to humans and livestock. While humans should not eat grains with DON concentrations above 1 ppm, some livestock can consume grain with up to 10 ppm DON, depending on the species and proportion of their diet which includes DON contaminated grain. Fungicide applications have proven to be relatively effective at controlling FHB in spring wheat in other growing regions. Limited work has been done in this region on the optimum timing for fungicide application on spring wheat to minimize DON. There are few studies evaluating organic-approved biofungicides, biochemicals, or biostimulants for the management of FHB. In 2019, the UVM Extension Northwest Crops and Soils (NWCS) Program conducted a spring wheat fungicide trial to determine the efficacy and timing of fungicide application (organic approved and conventional) to reduce FHB infection and subsequent mycotoxin production on hard red spring wheat cultivars with varying degrees of disease susceptibility.

MATERIALS AND METHODS

The experimental design was a randomized complete block, consisting of two cultivars and eleven fungicide+timing treatments with four replicates (Table 1). On 29-Apr, Glenn and Shelly hard red spring wheat were planted at Borderview Research Farm in Alburgh, VT, at 350 live seeds m^2 with a Great Plains Cone Seeder in 5'x 20' plots. The seedbed was prepared by conventional tillage methods with a moldboard plow, then a disc and spike tooth harrow. The previous crop was corn.

Table 1. Spring wheat fungicide trial specifics for Alburgh, VT, 2019.

	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Corn
Tillage operations	Spring plow, disc & spike tooth harrow
Row spacing (inches)	7
Plot size and harvest area (feet)	5' x 20'
Seeding rate (live seed m^2)	350
Replicates	4
Varieties	Shelly and Glenn
Planting date	29-Apr
Harvest date	2-Aug

Glenn is a FHB resistant variety of hard red spring wheat while Shelly is moderately resistant. The fungicide+timing treatments are listed in Table 2. Listed below are the descriptions of the fungicide treatments provided by the manufacturer.

Table 2. Plot treatments-fungicide application rates.

Treatments	Application rate
Control	Water
Caramba	14 fl oz ac^{-1} +.125% Induce ac^{-1}
ChampION	1.5 lbs ac^{-1}
Miravis Ace	13.7 fl oz ac^{-1}+ .125% Induce ac^{-1}
Prosaro	6.5 fl oz ac^{-1} +.125% Induce ac^{-1}
Fusarium graminearum	40,000 spores/ml

Caramba® (EPA# 7969-246) fungicide is a highly effective fungicide containing the active ingredient metconazole, resulting in significant yield protection and reductions of deoxynivalenol (DON) levels in grain. It is not only effective on head scab, but provides control of late-season foliar diseases as well.

ChampION® (EPA# 55146-1) is a 77% copper hydroxide-based, broad-spectrum fungicide for disease control. When copper hydroxide is mixed with water, it releases copper ions, which disrupt the cellular proteins of the fungus. This product is approved for use in organic production systems.

Miravis® Ace (EPA# 100-1601) is a combination of propiconazole and Adepidyn®fungicide – the first SDHI mode of action available for *Fusarium* head blight control. It distributes evenly within the leaf and creates a reservoir within the wax layer of the leaf that withstands rain and degradation. It also provides protection against Septoria leaf spot and other foliar disease.

Prosaro® (EPA# 264-862) fungicide provides broad-spectrum disease control, stops the penetration of the fungus into the plant and the spread of infection within the plant and inhibits the reproduction and further growth of the fungus.

Cold and erratic weather in the early growing season resulted in marked differences in maturity between varieties. Each variety was treated as it reached the appropriate state of maturity (Table 3). Each variety was treated with fungicides at anthesis (when 50% of the plot was flowering) and at five days after anthesis. One plot in each replicate was treated with ChampION at both anthesis and five days post anthesis. All but the control plots of each cultivar were inoculated with *Fusarium* before the flowering treatment. Water was applied at the same rate as the fungicides to the control plots and to those that were only inoculated with *Fusarium.* The applications were performed with a Bellspray Inc. Model T4 backpack sprayer, which had a carbon dioxide pressurized tank and a four-nozzle boom attachment. It sprayed at a rate of 10 gallons ac^{-1}.

Table 3. Fungicide treatment application dates, 2019.

Variety and treatment	Application date
Glenn Inoculated with *Fusarium*	24-Jun
Glenn Heading Applications	24-Jun
Glenn Post-heading Applications	29-Jun
Shelly Inoculated with *Fusarium*	29-Jun
Shelly Heading Applications	29-Jun
Shelly Post-Heading Applications	2-Jul

Grain plots were harvested with an Almaco SPC50 plot combine on 2-Aug. The harvest area was 5' x 20'. Following harvest, seed was cleaned with a small Clipper cleaner (A.T. Ferrell, Bluffton, IN). A one-pound subsample was collected to determine DON concentrations. At the time of harvest, grain moisture and test weight were recorded with a DICKEY-John M20P meter, and yield was measured on a pound scale. Generally, the heavier the wheat is per volume, the higher baking quality. The acceptable test weight for bread wheat is approximately 56-60 lbs bu^{-1}. Subsamples were ground into flour using a Perten LM3100 Laboratory Mill in order to be evaluated for mycotoxin levels. Deoxynivalenol (DON) analysis was conducted with the Veratox DON 5/5 Quantitative test from the NEOGEN Corp., which has a detection range of 0.5 to 5 ppm. Samples with DON values greater than 1 ppm are considered unsuitable for human consumption.

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 1999). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p<0.10$. Variations in genetics, soil, weather, and other growing conditions can result in variations in yield and quality. Statistical analysis makes it possible to determine whether a difference between treatments is significant or whether it is due to natural variations in the plant or field. At the bottom of each table, a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown. This means that when the difference between two treatments within a column is equal to or greater to the LSD value for the column, there is a real difference between the treatments 90% of the time. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk.

In the example to the right, treatment C was significantly different from treatment A, but not from treatment B. The difference between C and B is 1.5, which is less than the LSD value of 2.0 and so these treatments were not significantly different in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these treatments were significantly different from one another. The asterisk indicates that treatment B was not significantly lower than the top yielding treatment, indicated in bold.

Treatment	Yield
A	6.0
B	7.5*
C	**9.0**
LSD	2.0

RESULTS

Seasonal precipitation and temperature recorded at a weather station at Borderview Research Farm are shown in Table 4. April, May, and June were all colder than normal. April and May had higher precipitation than the 30-year average, while June was somewhat drier. July was both hotter and drier than the 30-year average. From April through July, there was an accumulation of 3261 Growing Degree Days (GDDs), 91 GDDs below the 30-year average.

Table 4. Temperature and precipitation summary for Alburgh, VT, 2019.

Alburgh, VT	April	May	June	July
Average temperature (°F)	42.7	53.3	64.3	73.5
Departure from normal	-2.11	-3.11	-1.46	2.87
Precipitation (inches)	3.65	4.90	3.06	2.34
Departure from normal	0.83	1.45	-0.63	-1.81
Growing Degree Days (32-95°F)	346	660	970	1286
Departure from normal	-38	-96	-44	88

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of data provided by the NOAA (1981-2010) for Burlington, VT.

Wheat Variety x Fungicide+Timing Interactions

There were no significant interactions between spring wheat variety and fungicide type and timing of application. This indicates that the varieties responded similarly to the fungicide x timing treatments.

Impact of Fungicide and Timing

There were significant differences between fungicide treatments in test weight, yield and DON concentrations (Table 5, Figure 1). There were no significant differences in harvest moisture.

Table 5. The impact of application timing and fungicide on spring wheat yield and quality, Alburgh, VT, 2019.

Treatment	**Harvest moisture**	**Test weight**	**Yield at 13.5% moisture**	**DON**
	%	lbs bu^{-1}	lbs ac^{-1}	ppm
Caramba 5 days after anthesis	21.7	55.7^{abc}	3198^{b}	0.18^{cd}
Caramba anthesis	21.4	55.6^{abc}	3866^{ab}	0.06^{ab}
ChampION 5 days after anthesis	19.9	**56.5^{a}**	**5560^{a}**	0.20^{de}
ChampION anthesis	21.4	55.8^{abc}	3215^{b}	0.19^{cd}
ChampION two applications	20.4	56.2^{ab}	3430^{b}	0.24^{de}
Uninoculated, untreated control	**19.8**	56.3^{ab}	3271^{b}	**0.03^{a}**
Inoculated with *Fusarium*	21.1	56.4^{ab}	3590^{b}	0.30^{e}
Miravis Ace 5 days after anthesis	20.3	54.9^{abc}	2411^{b}	0.16^{bcd}
Miravis Ace anthesis	21.1	54.5^{bc}	3352^{b}	0.09^{abc}

Prosaro 5 days after anthesis	21.1	55.6[abc]	3030[b]	0.26[de]
Prosaro anthesis	21.2	54.3[b]	3194[b]	0.19[cd]
LSD (0.10)	NS	1.9	1928	0.11
Trial mean	20.9	55.6	3465	0.17

Treatments within a column with the same letter are statistically similar.
Top performing treatments are shown in **bold**.
LSD – Least significant difference.
NS – No significant difference.

The highest test weight was in the ChampION treatment applied five days after anthesis at 56.5 lbs bu^{-1}. This was significantly similar to the test weights of all other treatments except Prosaro applied at anthesis and Miravis Ace applied at anthesis.

The highest yield in the trial was ChampION applied five days after anthesis, at 5560 lbs ac^{-1}. This was statistically similar to the yield of Caramba applied at anthesis (3866 lbs ac^{-1}).

All DON concentrations in the trial were below the USDA threshold for human consumption of 1 ppm. The highest DON concentrations were in the plots that were inoculated with Fusarium but not treated with fungicide. The lowest DON concentrations were in the uninoculated control. Two fungicide treatments were statistically similar in DON concentrations to the inoculated control: Caramba applied at anthesis and Miravis Ace applied at anthesis.

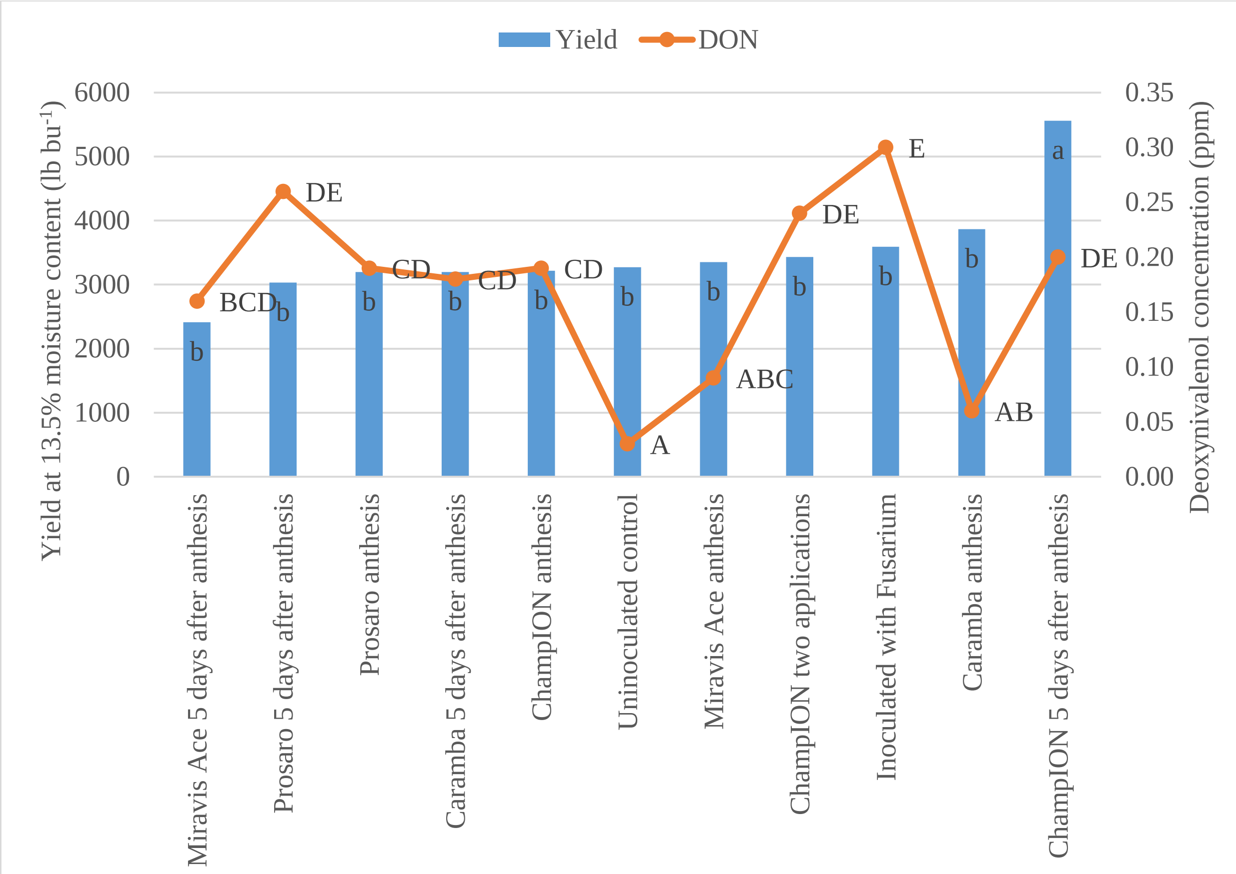

Figure 1. The impact of application timing and fungicide on spring wheat yield and DON concentration. Treatments with the same letter did not differ significantly by DON concentration (capital letters) or yield (lowercase).

Impact of Variety

There were significant differences between varieties in test weight, with Shelly having a significantly higher test weight at 56.1 lbs bu^{-1}. Glenn had a higher yield and Shelly had a lower DON concentration, but these differences were not statistically significant.

Table 6. The impact of spring wheat variety of quality and yield, Alburgh, VT, 2019.

Variety	Harvest moisture	Test weight	Yield @13.5% moisture	DON
	%	lbs bu^{-1}	lbs ac^{-1}	ppm
Glenn	**20.8**	55.2*	**3561**	0.172
Shelly	20.9	**56.1***	3370	**0.170**
LSD (0.10)	NS	0.80	NS	NS
Variety Mean	20.9	55.7	3466	0.171

*Treatments with an asterisk are not significantly different than the top performer in **bold**.

LSD – Least significant difference.

NS – No significant difference.

DISCUSSION

Levels of *Fusarium* infection and resulting DON vomitoxin concentrations in wheat are associated with weather conditions at the time of grain fill and flowering. Colder, wetter weather through this period is associated with more *Fusarium* infection and higher levels of DON. While the spring weather was very cold and wet during the early growing season, this delayed maturity until weather warmed in June. While wheat was late to flower (about a week later than normal), by the second half of June the weather was warmer and much drier than it had been earlier in the season and conditions were not conducive for fungal infection and development of the DON vomitoxin. There were low DON concentrations throughout the small grains trials, including the fungicide trials. The weather remained mild through the rest of the growing season and produced good wheat yields and quality at harvest.

All fungicide treatments were effective in reducing DON concentrations below that of the untreated plots. None reduced concentrations below those in the uninoculated control.

While it is interesting to note that yields were remarkably high in one of the ChampION copper fungicide treatments, it is unlikely that this was due to a copper deficiency in the soil as the other ChampION treatments were not similarly high yielding.

It is important to remember that the results only represent one year of data and to consider results from previous years or other fungicide trials while making management decisions. This trial is expected to continue for additional years.

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