NORTHWEST CROPS & SOILS PROGRAM

The Efficacy of Spraying Organic Fungicides to Control Fusarium Head Blight Infection in Spring Wheat

Dr. Heather Darby, UVM Extension Agronomist
Erica Cummings, UVM Extension Crops and Soils Coordinator
(802) 524-6501

Visit us on the web: http://www.uvm.edu/extension/cropsoil

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

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

Dr. Heather Darby, University of Vermont Extension
Heather.Darby[at]uvm.edu

There is a high demand for locally grown wheat for baking purposes throughout the Northeast. One major obstacle for growers is *Fusarium* head blight (FHB) infection of grain. This disease is currently the most important disease facing organic and conventional grain growers in the Northeast, resulting in loss of yield, shriveled grain, and most importantly, mycotoxin contamination. A vomitoxin called deoxynivalenol (DON) is considered the primary mycotoxin associated with FHB. Eating contaminated grain with DON concentrations greater than 1ppm poses a health risk to both humans and livestock. The FHB spores are usually transported by air currents and can infect plants at flowering through grain fill. Fungicide applications have proven to be relatively effective at controlling FHB in other spring wheat growing regions. Limited work has been done in this region on the optimum timing for a fungicide application to spring wheat specifically to minimize DON. In addition, there are limited studies evaluating organic approved biofungicides, biochemicals, or biostimulants for management of this disease. In April 2017, the UVM Extension Northwest Crops and Soils Program initiated a spring wheat fungicide trial to determine the efficacy and timing of fungicide application to reduce FHB infection on cultivars with varying degrees of disease susceptibility.

MATERIALS AND METHODS

A field experiment was established at the Borderview Research Farm located in Alburgh, VT on 25-Apr to investigate the effects of cultivar resistance, fungicide efficacy, and application timing on FHB and DON infection in spring wheat. The experimental design was a randomized complete block, with a split-plot arrangement of cultivar as the whole-plot and fungicide+timing treatments as the sub-plots. The main plot of cultivar included Prosper, a hard red spring wheat with moderately FHB resistant, and Glenn, a hard red spring wheat a FHB resistant variety. The fungicide+timing treatments are listed in Table 2.

The seedbed at the Alburgh location was prepared by conventional tillage methods. All plots were managed with practices similar to those used by producers in the surrounding areas (Table 1). The previous crop planted at the site was corn. Prior to planting, the trial area was disked and spike tooth harrowed to prepare for planting. The plots were seeded with a Great Plains Cone Seeder on 25-Apr at a seeding rate of 350 live seeds per m^2. Plot size was 5'x 20'.

When the wheat reached 75-100% flowering (28-Jun), plots were sprayed with the fungicide treatments (Table 2). All but one plot (Control) of each cultivar was inoculated 3 hours (28-Jun), after the flowering treatment was applied, with a spore suspension (40,000 spores/ml) consisting of a mixture of isolates of *Fusarium graminearum* endemic to the area. The *Fusarium graminearum* spores were multiplied and harvested using the 'Gz conidial suspension inoculum protocol'. Five days after the flowering application (3-Jul) plots not previously treated with a fungicide were sprayed with the fungicides treatments except for the control and *Fusarium graminearum* only plots (Table 2). Water was applied at the same rate as the

fungicides to the control plots and to those that were only inoculated with *Fusarium graminearum.* The applications were performed with a Bellspray Inc. Model T4 backpack sprayer. This model had a carbon dioxide pressurized tank and a four-nozzle boom attachment. It sprayed at a rate of 10 gallons per acre. Below is a list of the treatment materials evaluated in this trial. Descriptions have been provided from manufacturer information.

Table 1. General plot management of the trial.

Trial Information	
Location	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	corn
Row spacing (inch)	7
Seeding rate (live seed m^2)	350
Replicates	4
Varieties	Prosper and Glenn
Planting date	25-Apr
Harvest date	9-Aug
Harvest area (ft)	5 x 20
Tillage operations	Spring plow, disk & spike tooth harrow

Actinovate® (EPA# 73314-1) is a biological fungicide (0.0371% Streptomyces lydicus WYEC 108) that suppresses and controls root rot, damping-off fungi and foliar fungal pathogens. Its active ingredient is a patented bacterium that grows around the root system (when soil drenched) and foliage of the plant (when sprayed on) while using several novel modes of antifungal action to protect plants.

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.

Champ WG (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.

Regalia (EPA # 85059-3) bio fungicides have a unique and complex mode of action, referred to as Induced Systemic Resistance (ISR), and carry a FRAC code of P5. ISR creates a defense response in the treated plants and stimulates additional biochemical pathways that strengthen the plant structure and act against the pathogen. When applied to crops, Regalia products activate ISR and induce the plants to produce specialized proteins and other compounds—phytoalexins, cell strengtheners, antioxidants, phenolics, and PR proteins—which are known to inhibit fungal and bacterial diseases and also improve plant health and vigor. This product is approved for use in organic production systems.

SONATA® (EPA# 69592-13) fungicide provides excellent control of powdery mildews and rusts. Based on a patented strain of Bacillus pumilus (QST 2808), SONATA is an excellent fit for integrated disease management programs. SONATA contains a unique, patented strain of Bacillus pumilus (QST 2808) that produces an antifungal amino sugar compound that inhibits cell metabolism. SONATA also creates a zone of inhibition on plant surfaces, preventing pathogens from establishing on the plant.

Table 2. Treatments-fungicide application dates and rates.

Treatments	Flowering application	5 days after flowering application	Application rate
	date	date	
Control	28-Jun	3-Jul	Water
Fusarium graminearum	28-Jun (3 hours after flowering application)		40,000 spores/ml
Actinovate	28-Jun	3-Jul	6 fl oz ac^{-1}
ChampION	28-Jun	3-Jul	1.5 lbs ac^{-1}
Champ WG	28-Jun	3-Jul	1 lbs ac^{-1}
Regalia	28-Jun	3-Jul	1 qt. ac^{-1}
SONATA	28-Jun	3-Jul	2 qt. ac^{-1}

When the wheat reached the soft dough growth stage (12-Jul), FHB intensity was assessed by randomly clipping 60-100 heads throughout each plot, spikes were counted and a visual assessment of each head was rated for FHB infection. The level of infection rate was determined by using the North Dakota State University Extension Service's "A Visual Scale to Estimate Severity of Fusarium Head Blight in Wheat" online publication.

Grain plots were harvested in Alburgh with an Almaco SPC50 plot combine on 9-Aug, the harvest area was 5' x 20'. At the time of harvest grain moisture, test weight, and yield were calculated.

Following harvest, seed was cleaned with a small Clipper cleaner (A.T. Ferrell, Bluffton, IN). An approximate one-pound subsample was collected to determine quality. Quality measurements included standard testing parameters used by commercial mills. Test weight was measured by the weighing of a known volume of grain. Generally, the heavier the wheat is per bushel, the higher baking quality. The acceptable test weight for bread wheat is 56-60 lbs per bushel. Once test weight was determined, the samples were then ground into flour using the Perten LM3100 Laboratory Mill. At this time flour was evaluated for mycotoxin levels. Deoxynivalenol (DON) analysis was analyzed using Veratox DON 5/5 Quantitative test from the NEOGEN Corp. This test has a detection range of 0.5 to 5 ppm. Samples with DON values greater than 1 ppm are considered unsuitable for human consumption.

All data was analyzed using a mixed model analysis where replicates were considered random effects. The LSD procedure was used to separate treatment means when the F-test was significant ($P< 0.10$).

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among varieties is real or whether it might have occurred due to other variations in the field. At the bottom of each table a LSD value is presented for each variable (e.g. yield). Least Significant Differences at the

10% level of probability are shown. Where the difference between two varieties within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two varieties. In the following example, variety A is significantly different from variety C, but not from variety B. The difference between A and B is equal to 725, which is less than the LSD value of 889. This means that these varieties did not differ in yield. The difference between A and C is equal to 1454, which is greater than the LSD value of 889. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that variety B was not significantly lower than the top yielding variety.

Variety	Yield
A	3161
B	3886*
C	**4615***
LSD	**889**

RESULTS

Seasonal precipitation and temperature recorded at weather stations in close proximity to the 2017 site are shown in Table 3. The growing season this year was marked by higher than normal temperatures in April and lower than average temperatures in May, June, July, and August. Rainfall amounts were higher than average throughout the growing season resulting in 7.39 inches of precipitation more than normal. From April to August, there was an accumulation of 4440 Growing Degree Days (GDDs), 50.9 GDDs below the 30-year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2017.

Alburgh, VT	April	May	June	July	August
Average temperature (°F)	47.2	55.7	65.4	68.7	67.7
Departure from normal	2.37	-0.75	-0.39	-1.90	-1.07
Precipitation (inches)	5.22	4.13	5.64	4.88	5.54
Departure from normal	2.40	0.68	1.95	0.73	1.63
Growing Degree Days (32-95°F)	459	733	1002	1138	1108
Departure from normal	75.4	-22.7	-11.9	-60.3	-31.4

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 treatments.

Impact of Fungicide and Timing:

There were no significant differences in the average FHB severity, FHB infected head severity, and incidence of infected heads between fungicide+timing treatments (Table 4).

Table 4. The FHB incidence and severity following fungicide treatments at flowering and five days after flowering, Alburgh, VT 2017.

Treatment	Average FHB severity	Average FHB infected head severity	Incidence FHB of infected heads
	%	%	%
Non-sprayed, non-inoculated control	**1.75**	10.7	**17.5**
Inoculated Fusarium spores 23-Jun	3.55	11.9	26.6
Actinovate – anthesis	2.01	**9.57**	21.0
Actinovate – 5 days after anthesis	3.07	10.8	27.6
ChampION – anthesis	2.76	12.2	21.7
ChampION – 5 days after anthesis	2.44	10.3	23.2
ChampWG - heading	3.03	14.5	19.7
ChampWG – 5 days after anthesis	3.48	13.2	25.8
Regalia – anthesis	2.92	14.6	20.5
Regalia– 5 days after anthesis	2.41	11.0	20.0
Sonota – anthesis	3.37	10.6	28.4
Sonota – 5 days after anthesis	3.17	11.9	25.1
LSD (0.10)	NS	NS	NS
Trial Mean	2.83	11.8	23.1

Values shown in **bold** are of the highest value or top performing.
NS - None of the treatments were significantly different from one another.

There were no significant difference in harvest moisture, test weight, yield, and DON concentration between fungicide+timing treatments (Table 5). All fungicide+timing treatments had moistures above 14%, the optimum moisture for grain storage, and therefore had to be dried to meet storage moisture requirements. None of the fungicide+timing treatments met industry standards of 60 lbs bu^{-1} for wheat. The fungicide+treatment with the highest yield (2,385 lbs ac^{-1}) and lowest DON concentrations (3.74 ppm) was the non-sprayed, non-inoculated control. (Figure 1). All fungicide+timing treatments had DON concentrations that exceeded the FDA 1 ppm recommendation.

Table 5. The impact application timing and fungicide on spring wheat yield and quality.

Treatment	Harvest moisture	Test weight	Yield @13.5% moisture	DON
	%	lbs bu^{-1}	lbs ac^{-1}	ppm
Non-sprayed, non-inoculated control	17.0	57.2	**2385**	**3.74**
Inoculated Fusarium spores 23-Jun	16.9	57.2	2217	4.95
Actinovate – anthesis	17.1	57.0	2121	5.05
Actinovate – 5 days after anthesis	16.6	54.9	1996	4.90
ChampION – anthesis	16.6	**58.0**	2270	5.21
ChampION – 5 days after anthesis	17.1	57.0	2283	5.14
ChampWG - heading	**16.4**	57.1	2175	4.90
ChampWG – 5 days after anthesis	16.8	56.2	2062	4.73
Regalia – anthesis	16.9	56.7	2113	5.38
Regalia– 5 days after anthesis	16.9	56.0	2270	5.83
Sonota – anthesis	17.2	57.2	2240	5.34
Sonota – 5 days after anthesis	17.0	57.8	2096	5.48
LSD (0.10)	NS	NS	NS	NS
Trial Mean	16.9	56.8	2186	5.05

Values shown in **bold** are of the highest value or top performing.
NS - None of the treatments were significantly different from one another.

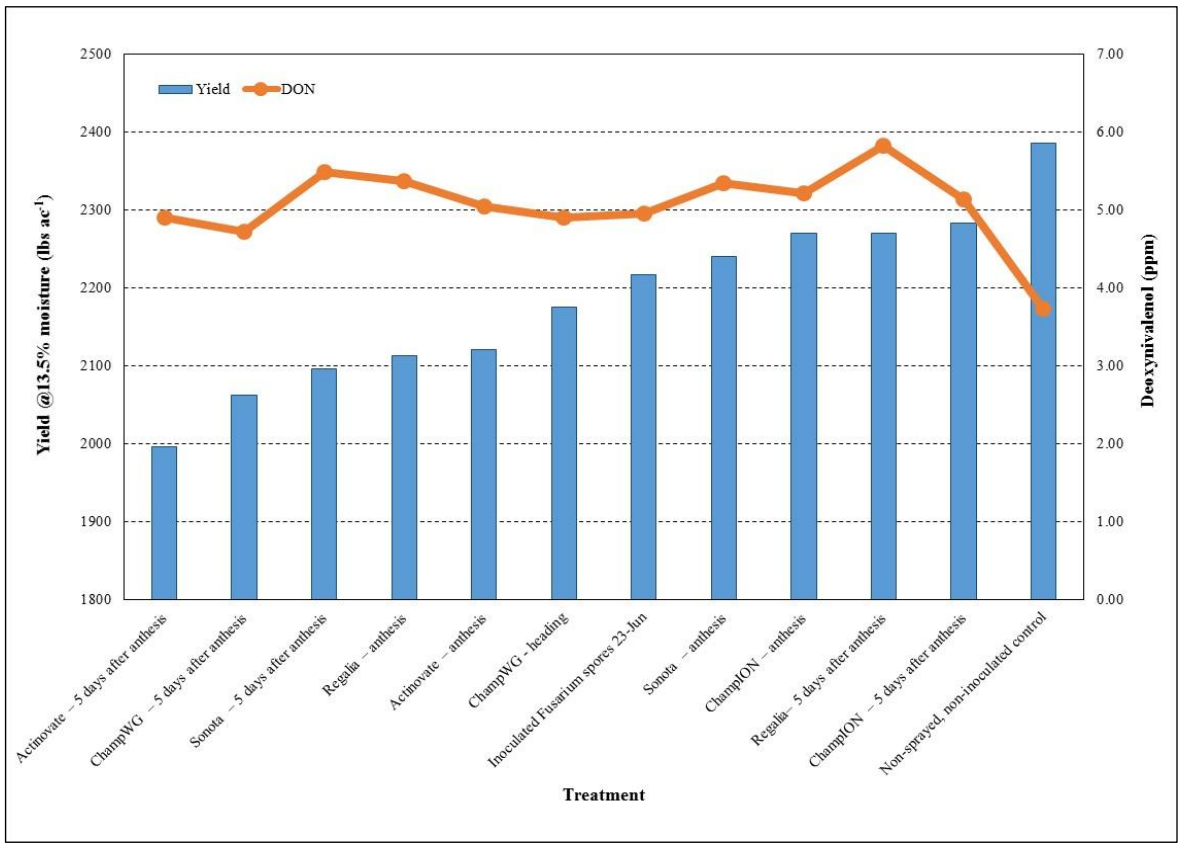

Figure 1. The impact of application timing and fungicide on spring wheat yield and DON concentration.

Impact of Variety:

There were no significant differences in the average FHB plot severity, FHB infected head severity, and incidence of FHB infection between spring wheat varieties (Table 6).

Table 6. The impact of spring wheat variety of FBH incidence and severity.

Variety	Average FHB severity	Average FHB infected head severity	Incidence FHB of infected heads
	%	%	%
Glenn	3.05	**11.8**	24.4
Prosper	**2.61**	**11.8**	**21.8**
LSD (0.10)	NS	NS	NS
Trial Mean	2.83	11.8	23.1

Values shown in **bold** are of the highest value or top performing.
NS - None of the varieties were significantly different from one another.

The spring wheat varieties were significantly different in yield and DON concentration (Table 7, Figure 2). Prosper was the highest yielding (2390 lbs ac^{-1}) and has the lowest DON concentration (4.65 ppm). Both varieties exceeded the FDA recommendation of 1ppm. Both varieties had moistures above 14% and therefore had to be dried down for storage. Neither of the varieties, achieved industry standards for test weight of 60 lbs bu^{-1}.

Table 7. The impact of spring wheat variety of quality and yield.

Variety	Harvest moisture	Test weight	Yield @13.5% moisture	DON
	%	lbs bu^{-1}	lbs ac^{-1}	ppm
Glenn	16.9	**57.2**	1981	5.45
Prosper	**16.8**	56.5	**2390**	**4.65**
LSD (0.10)	NS	NS	170	0.44
Trial Mean	16.9	56.8	2186	5.05

Values shown in **bold** are of the highest value or top performing.
NS - None of the varieties were significantly different from one another.

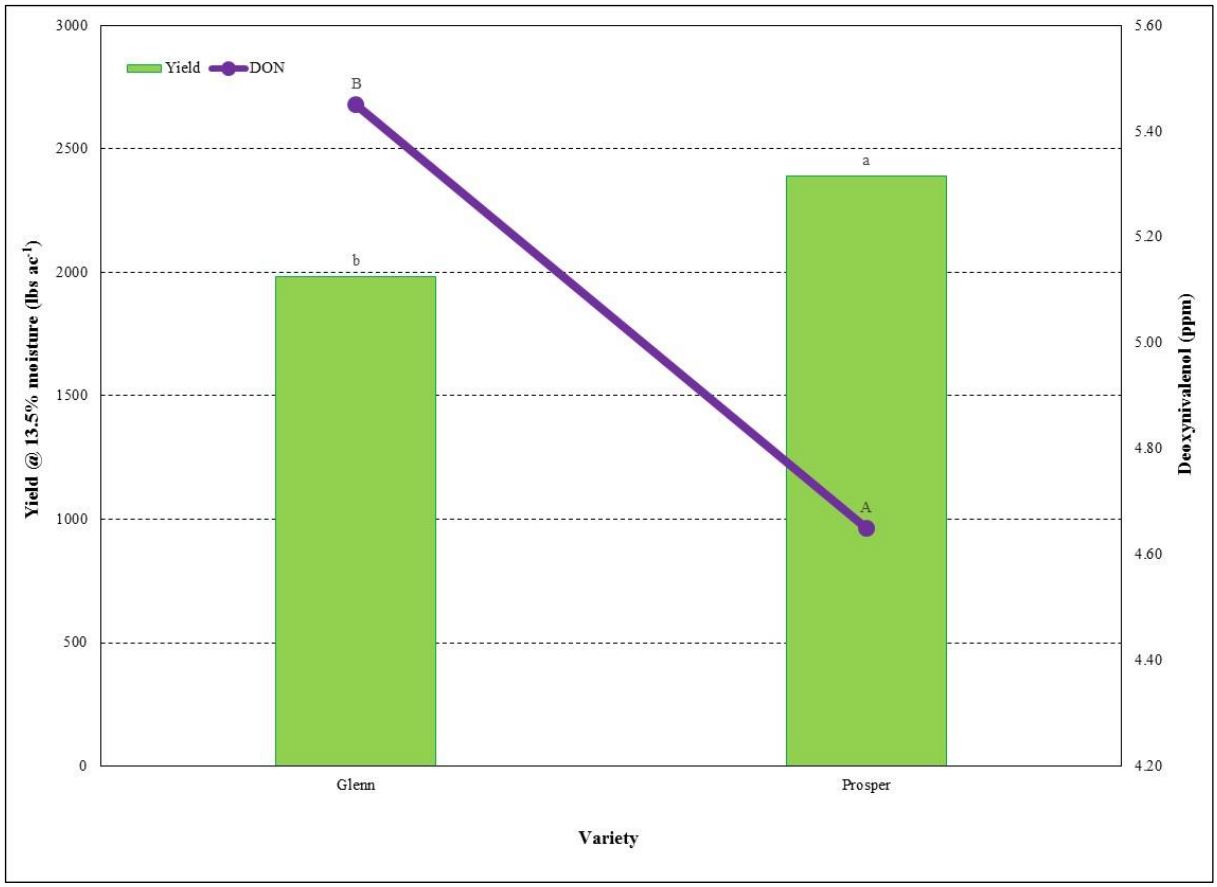

Figure 2. Impact of variety on spring wheat yields and DON concentrations.
Treatments with the same letter did not differ significantly.

DISCUSSION

Overall, the 2017 growing season was challenging for growing spring wheat. The cooler than average temperatures along with the higher than normal rainfall in throughout much of the growing season created the ideal conditions for Fusarium growth. This is evident in the high DON concentrations in both varieties.

The untreated control had the lowest DON concentrations; this could be attributed to these plots not being sprayed with Fusarium spores (40,000 spores per ml) indicating the impact of high Fusarium inoculum during plant flowering.

It is important to remember that the results only represent one year of data. The Northwest Crops and Soils program will be repeating this trial again in 2018.

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Team would like to thank the Borderview Research Farm for their generous help with the trials, as well as acknowledge the U.S. Wheat and Barley Scab Initiative program for their financial support. We would like to acknowledge Kelly Drollette, Hillary Emick, Abha Gupta, Freddy Morin, Lindsey Ruhl, Matt Sanders, Stuart Wolff-Goodrich and Sara Ziegler for their assistance with data collection and entry. This information is presented with the understanding that no product discrimination is intended and neither endorsement of any product mentioned, nor criticism of unnamed products, is implied.

UVM Extension helps individuals and communities put research-based knowledge to work.