The Efficacy of Spraying Fungicides to Control Fusarium Head Blight Infection in Spring Malting Barley

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 FUNGICIDES TO CONTROL FUSARIUM HEAD BLIGHT INFECTION IN SPRING MALTING BARLEY

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

Public interest in sourcing local foods has extended into beverages, and the current demand for local brewing and distilling ingredients is quickly increasing. One new market that has generated interest of both farmers and end-users is malted barley. This only stands to reason since the Northeast alone is home to over 180 microbreweries and 37 craft distillers. Until recently, local malt was not readily available to brewers or distillers. However, a rapid expansion of the fledgling malting industry will hopefully give farmers new markets and end-users hope of readily available malt. To date, the operating maltsters struggle to source enough local grain to match demand for their product. In addition to short supplies, the local barley that is available often does not meet the rigid quality standards for malting. 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. The spores are usually transported by air currents and can infect plants at spike emergence through grain fill. Eating contaminated grain greater than 1ppm poses a health risk to both humans and livestock.

Fungicide applications have proven to be relatively effective at controlling FHB in other barley growing regions. Limited work has been done in this region on the optimum timing for a fungicide application to barley 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 year four of a spring barley 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 27-Apr to investigate the effects of cultivar resistance, fungicide efficacy, application timing on FHB and DON infection in spring malting barley. 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 Rasmussen, a 6-row malting barley that is a FHB susceptible variety, and Conlon, a 2-row malting barley with moderate FHB resistance. 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 silage. 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 27-Apr at a seeding rate of 325 live seeds per m^2. Plot size was 5’x 20’.

Table 1. General plot management of the trial.

Location	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Corn silage
Row spacing (inch)	7
Seeding rate (live seed m^2)	325
Replicates	4
Varieties	Conlon and Rasmussen
Planting date	27-Apr
Harvest date	1-Aug
Harvest area (ft)	5 x 20
Tillage operations	Spring plow, disk & spike tooth harrow

When the barley reached 50% spike emergence (22-Jun), plots were sprayed with the fungicide treatments (Table 2). The adjuvant 'Induce' was added to the Prosaro and Caramba applications at a rate of 0.125%. All but one plot (Control) of each cultivar was inoculated 24 hours (23-Jun), after the heading 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'. Four days after the heading application (26-Jun) 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 application was made using 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.

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.

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.

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.

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. Plot treatments-fungicide application dates and rates.

Treatments	Heading application	4 days after heading application	Application rate
	date	date	
Control	22-Jun	26-Jun	Water
Fusarium graminearum	23-Jun		40,000 spores/ml
Actinovate	22-Jun	26-Jun	6 fl oz ac^{-1}
Caramba	22-Jun	26-Jun	14 fl oz ac^{-1} +.125% Induce ac^{-1}
ChampION	22-Jun	26-Jun	1.5 lbs ac^{-1}
Prosaro	22-Jun	26-Jun	6.5 fl oz ac^{-1} +.125% Induce ac^{-1}
SONATA	22-Jun	26-Jun	2 qt. ac^{-1}

When the barley 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 infection rate was assessed 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 1-Aug, the harvest area was 5' x 20'. At the time of harvest, grain moisture, test weight, and yield were calculated. Harvest moisture was determined for each plot using a DICKEY-john Mini GAC moisture and test weight meter. Generally the heavier the barley is per bushel, the higher malting quality. The acceptable test weight for barley is 48 lbs per bushel.

Following the harvest of spring barley, seed was cleaned with a small Clipper cleaner (A.T. Ferrell, Bluffton, IN). A one-pound subsample was collected to determine quality. Hundred kernel weights were measured in duplicate for each plot and then averaged. Once hundred kernel weights were 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 and the treatments and varieties were considered fixed effects. The LSD procedure was used to separate treatment and cultivar 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.

Barley Variety x Fungicide+Timing Interactions:

There were no significant interactions of variety by fungicide treatment and timing. Indicating that the varieties responded similar to the fungicide+timing treatments.

Impact of Fungicide and Timing

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

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

Treatment	Average FHB severity	Average FHB infected head severity	Incidence FHB of infected heads
	%	%	%
Non-sprayed, non-inoculated control	**3.26**	**9.81**	**31.9**
Inoculated Fusarium spores 23-Jun	6.37	11.8	48.7
Actinovate – heading	8.03	14.8	48.5
Actinovate – 4 days after heading	10.2	16.7	57.8
Caramba - heading	6.62	13.2	47.7
Caramba – 4 days after heading	5.25	12.0	41.4
ChampION - heading	6.92	13.1	52.3
ChampION – 4 days after heading	8.15	13.6	56.6
Prosaro - heading	5.02	11.2	40.2
Prosaro – 4 days after heading	7.60	14.0	51.3
Sonata - heading	7.30	13.3	49.8
Sonata – 4 days after heading	6.22	13.1	38.3
LSD (0.10)	NS	NS	NS
Trial Mean	6.75	13.1	47.1

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 significant differences in harvest moisture, test weight, hundred-kernel weight, and Deoxynivalenol (DON) concentration between fungicide+timing treatments (Table 5). The treatment with the lowest harvest moisture was Actinovate applied at heading (13.1%), Caramba applied 4-days after heading had the highest harvest moisture (15.8%). Prosaro applied at heading had the highest test weight of 46.1 lbs bu^{-1}, the lowest test weight was Actinovate applied at heading (42.8 lbs bu^{-1}). None of the fungicide+timing treatments met industry standards of 48 lbs bu^{-1} for barley. The heaviest hundred-kernel weight fungicide+timing treatment was Prosaro applied at heading (4.74 g), the lightest hundred-kernel weight was the treatment inoculated only with Fusarium spores (4.44 g). The treatment with the lowest DON concentration was Prosaro applied at heading (3.68 ppm) (Figure 1). Other fungicide+timing treatments with low DON concentrations include: the non-sprayed, non-inoculated control (4.28 ppm) and Caramba applied at heading (4.80 ppm). The fungicide+timing treatment with the highest DON concentration was Actinovate applied 4-days after heading (8.15 ppm). In regards to USDA NOP compliant materials, the ChampIon provided some reduction in DON compared to Actinovate and Sonata.

All fungicide+timing treatments had DON concentrations above the FDA 1 ppm recommendation. The fungicide+timing treatments did not differ statistically in yield.

Table 5. The impact application timing and fungicide on barley yield and quality, Alburgh, VT 2017.

Treatment	Harvest moisture	Test weight	Hundred-kernel weight	Yield @13.5% moisture	DON
	%	lbs bu^{-1}	grams	lbs ac^{-1}	ppm
Non-sprayed, non-inoculated control	14.6	44.9*	4.54	3128	4.28*
Inoculated Fusarium spores 23-Jun	14.2*	44.3	4.44	2595	7.91
Actinovate – heading	**13.1***	42.8	4.58	2746	7.69
Actinovate – 4 days after heading	13.9*	44.0	4.59	3141	8.15
Caramba - heading	15.5	45.1*	4.62*	2363	4.80*
Caramba – 4 days after heading	15.8	44.5	4.47	2907	6.57
ChampION - heading	14.1*	44.0	4.56	2869	5.74
ChampION – 4 days after heading	13.7*	43.9	4.48	2845	6.99
Prosaro - heading	15.0	**46.1***	**4.74**	2685	**3.68***
Prosaro – 4 days after heading	15.6	44.6	4.60*	2774	6.35
Sonata - heading	14.3*	43.6	4.49	2888	7.14
Sonata – 4 days after heading	14.2*	43.2	4.52	**3151**	7.64
LSD (0.10)	1.30	1.27	0.14	NS	1.32
Trial Mean	14.5	44.2	4.55	2841	6.41

* Treatments that are not significantly different than the top performing variety in a column shown in **bold** are indicated with an asterisk**.**
NS – No significant difference.

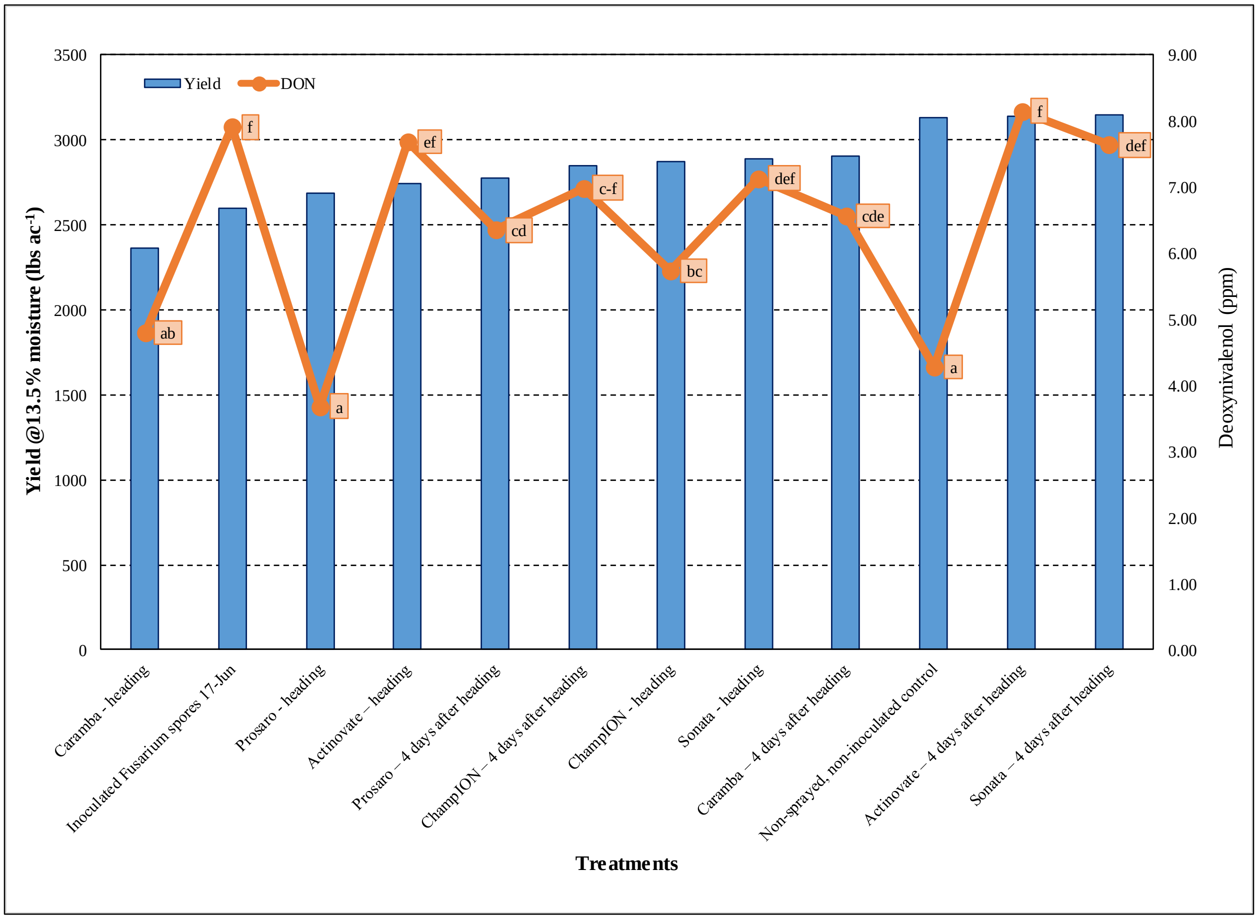

Figure 1. The impact of application timing and fungicide on barley yield and DON concentration. Treatments with the same letter did not differ significantly.

Impact of Variety

There were significant differences in the average FHB plot severity, infected head severity, and incidence of FHB infection between malting barley varieties (Table 6). The variety Conlon had the lowest average FHB plot severity (5.23%), infected head severity (11.2%), and incidence of FHB infected heads (42.3%).

Table 6. The impact of malting barley variety of FHB incidence and severity.

Variety	Average FHB severity	Average FHB infected head severity	Incidence FHB of infected heads
	%	%	%
Conlon	**5.23**	**11.2**	**42.3**
Rasmussen	8.26	14.9	51.8
LSD (0.10)	1.57	1.69	5.82
Trial Mean	6.75	13.1	47.1

Values shown in **bold** are of the highest value or top performing.

The malting barley varieties were significantly different in harvest moisture, test weight, hundred-kernel weight, and DON (Table 7, Figure 2). Rasmussen had the lowest harvest moisture (14.2%). Both varieties had moistures above 14% and therefore had to be dried down for storage. Conlon had the highest test weight of 44.5 lbs bu^{-1}, heaviest hundred-kernel weight (5.00 g) and the lowest DON concentration (4.53 ppm). Neither of the varieties achieved industry standards for test weight of 48 lbs bu^{-1}, and both had DON concentrations above the FDA 1 ppm recommendation. Varieties did not differ in yield (Figure 2).

Table 7. The impact of malting barley variety of quality and yield.

Variety	Harvest moisture	Test weight	Hundred kernel weight	Yield @13.5% moisture	DON
	%	lbs bu^{-1}	grams	lbs ac^{-1}	ppm
Conlon	14.8	**44.5**	**5.00**	2828	**4.53**
Rasmussen	**14.2**	43.9	4.11	**2854**	8.29
LSD (0.10)	0.53	0.52	0.06	NS	0.54
Trial Mean	14.5	44.2	4.55	2841	6.41

Values shown in **bold** are of the highest value or top performing.
NS – No significant difference.

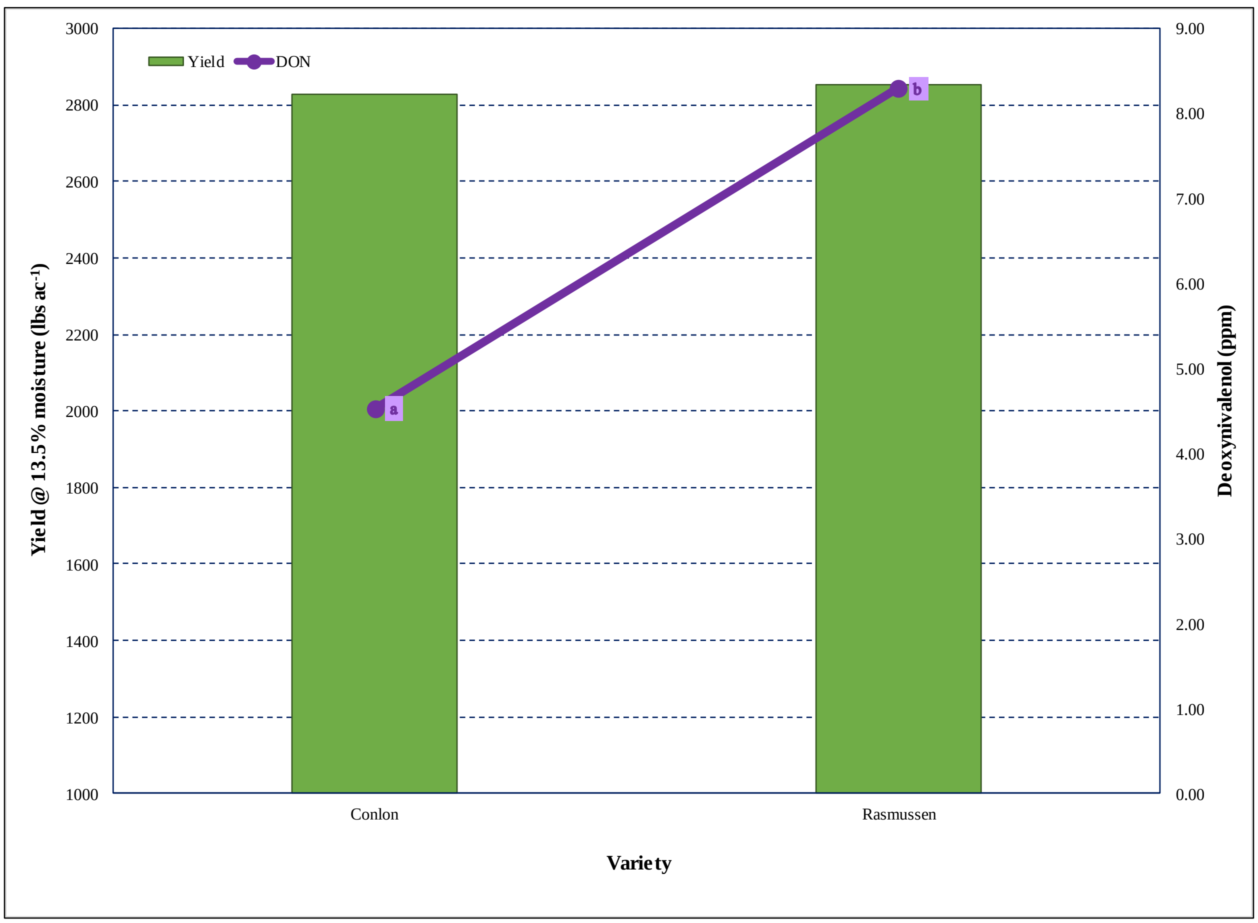

Figure 2. The impact of variety on barley yield and DON concentration. Treatments with the same letter did not differ significantly.

DISCUSSION

Overall, the 2017 growing season was challenging for growing spring barley. 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.

Even though all of the variety+fungicide+timing treatments resulted in DON concentrations above 1 ppm, it's important to note that Conlon, a moderately resistant variety, had lowest incidence of FHB and DON levels, while Rasmussen, a susceptible variety, had DON levels almost double (8.29 ppm) that of Conlon (4.53 ppm). This indicates the importance of selecting resistant cultivars to manage FHB in our region.

The application of the conventional fungicides Prosaro and Caramba, applied at heading, reduced DON concentrations. However, the untreated control also had low 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 heading and flowering. In general, the fungicide applications at heading resulted in lower DON concentrations than the fungicides applied 4-days after heading. Interestingly, yields did not vary significantly between fungicide type, application or variety.

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.

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES