NORTHWEST CROPS & SOILS PROGRAM

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

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UNIVERSITY OF VERMONT EXTENSION
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# THE EFFICACY OF SPRAYING FUNGICIDES TO CONTROL FUSARIUM HEAD BLIGHT INFECTION IN SPRING MALTING BARLEY

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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 175 microbreweries and 35 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 malt 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 flowering 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. No 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 fungicides or biostimulants for management of this disease. In April of 2014, the UVM Extension Northwest Crops and Soils program initiated 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 29-Apr to investigate the effects of cultivar resistance, fungicide efficacy, application timing on FHB and DON infection in spring malt 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 which 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 no-till corn. Prior to planting the trial area was disked and spike tooth harrowed to prepare for planting. The plots were seeded with a Sunflower seed drill on 29-Apr at a seeding rate of 123 lbs $ac^{-1}$. Plot size was 10’x 20’.

**Table 1. General plot management of the trial.**

| Trial Information | |
|---|---|
| **Location** | Borderview Research Farm Alburgh, VT |
| **Soil type** | Benson rocky silt loam |
| **Previous crop** | No-till corn |
| **Row spacing (inch)** | 7 |
| **Seeding rate (lbs ac$^{-1}$)** | 123 |
| **Replicates** | 4 |
| **Varieties** | Conlon and Rasmussen |
| **Planting date** | 29-Apr |
| **Harvest date** | 4-Aug |
| **Harvest area (ft)** | 5 x 20 |
| **Tillage operations** | Fall plow, spring disk & spike tooth harrow |

When the barley reached 50% anthesis (27-Jun), plots were sprayed with one of three fungicides (Table 2). The application was made using a Schaben 3-point Sprayer-110-gallon-8 Pump Roller calibrated to deliver at a rate of 10 gallons per acre. The adjuvant 'Induce' was added to the Porsaro application at a rate of 0.125%. All but one plot (Control) of each cultivar was inoculated 36 hours (29-Jun), after the anthesis treatment was applied, with a spore suspension (5,830 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'. Ten days after anthesis (8-Jul), a post-anthesis fungicide spray was applied (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.*

**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.

**Camp 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.

**Table 2. Plot treatments-Fungicide and *Fusarium* application dates and rates.**

| Treatments | Anthesis application | Post-anthesis application | Application rate | *Fusarium* application | Fusarium concentration |
|---|---|---|---|---|---|
| | date | date | | date | spores/ml |
| Control | 27-Jun | 8-Jul | water | 29-Jun | water |
| *Fusarium graminearum* | 27-Jun | 8-Jul | water | 29-Jun | $5.83 \times 10^3$ |
| Champ | 27-Jun | 8-Jul | 1 lb $ac^{-1}$ | 29-Jun | $5.83 \times 10^3$ |
| Porsaro | 27-Jun | 8-Jul | 6.5 fl oz $ac^{-1}$, (+ 0.125% Induce) | 29-Jun | $5.83 \times 10^3$ |
| Regalia | 27-Jun | 8-Jul | 1 qt $ac^{-1}$ | 29-Jun | $5.83 \times 10^3$ |

When the barley reached the soft dough growth stage, 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. To assess the infection rate we use 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 4-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 cultivar means when the F-test was significant ($P< 0.10$). There were significant differences among the two locations for most parameters and therefore data from each location is reported independently.

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 2014 site are shown in Table 3. The growing season this year was marked by lower than normal temperatures in April, July, and August and higher than normal rainfall throughout the growing season (Apr-Aug). From April to August, there was an accumulation of 4510 Growing Degree Days (GDDs) in Alburgh which is 53 GDDs below the 30 year average.

**Table 3. Temperature and precipitation summary for Alburgh, VT, 2014.**

| **Alburgh, VT** | April | May | June | July | August |
|---|---|---|---|---|---|
| Average temperature (°F) | 43.0 | 57.4 | 66.9 | 69.7 | 67.6 |
| Departure from normal | -1.80 | 1.00 | 1.10 | -0.90 | -1.20 |
| | | | | | |
| Precipitation (inches) | 4.34 | 4.90 | 6.09 | 5.15 | 3.98 |
| Departure from normal | 1.52 | 1.45 | 2.40 | 1.00 | 0.07 |
| | | | | | |
| Growing Degree Days (base 32°F) | 330 | 789 | 1041 | 1171 | 1108 |
| Departure from normal | -53.9 | 32.8 | 27.3 | -26.9 | -30.9 |

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
October data represents weather recorded through the last corn harvest, 14-Oct 2014.
Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

***Barley Variety x Fungicide/Timing Interactions:***

There was a significant fungicide by variety interaction for DON concentrations. These interactions indicate that malting barley varieties respond differently to the different fungicides applied. The DON levels in the Conlon plots varied slightly between fungicide/timing treatments and were not significantly different (Figure 1). The Rasmussen plots were significantly different by fungicide/timing application.

The Posaro anthesis and post-anthesis treatments resulted in the lowest DON levels, and the Regalia anthesis and post-anthesis treatments resulted in the highest DON levels.

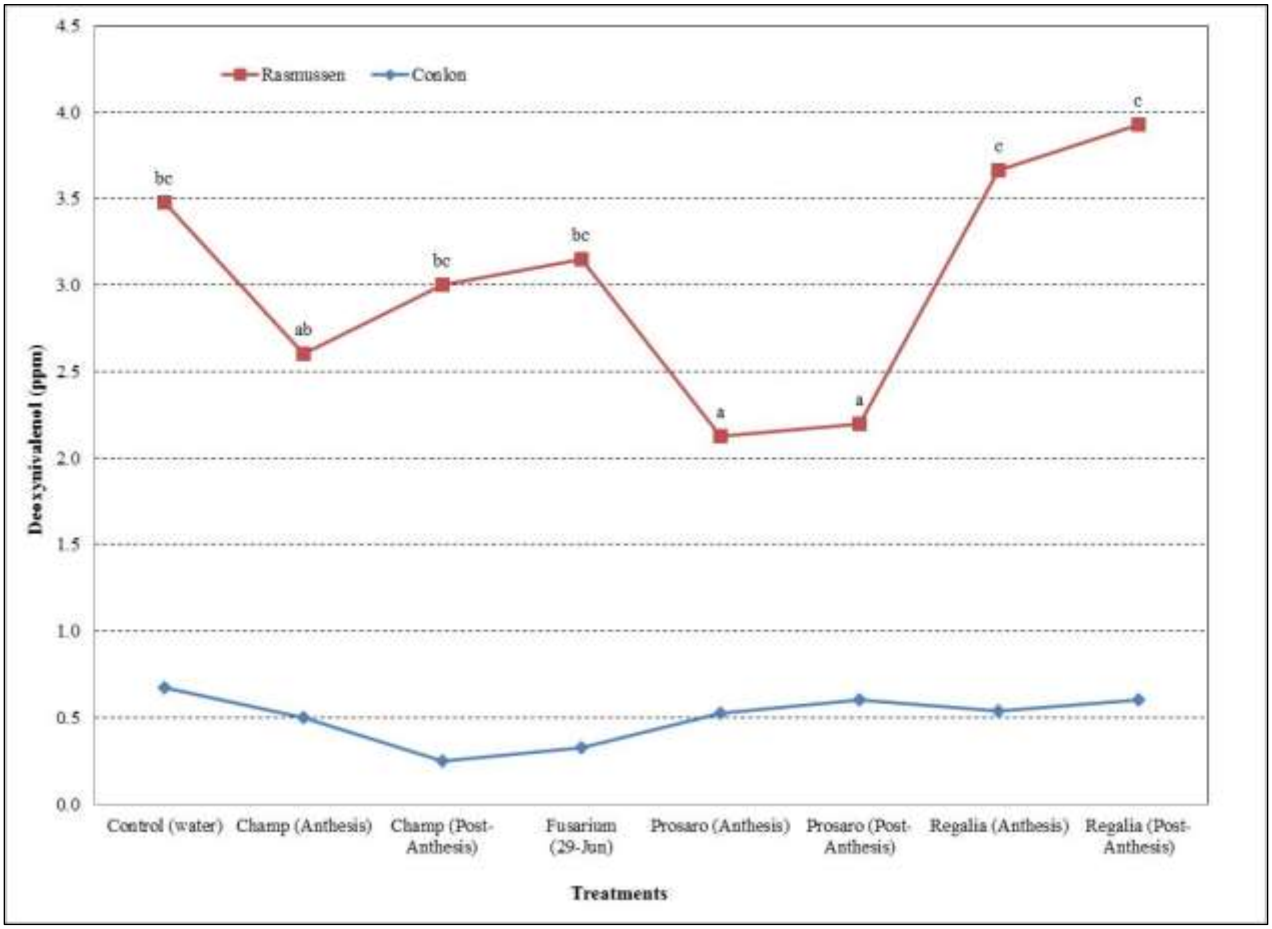


**Figure 1. Barley variety by fungicide interaction on Deoxynivalenol (DON) level.**
Treatments with the same letter did not differ significantly.

***Impact of Fungicide and Timing***

There were no significant differences in the average FHB plot severity, infected head severity, or incidence of infected heads between fungicide+timing treatments (Table 4). The Control had the lowest average FHB plot severity (2.47%) and the lowest infected head severity (10.1%). The post-anthesis Champ application had the lowest incidence of infected heads. The *Fusarium* inoculated plots had the highest average FHB plot severity (7.97%) and infected head severity (28.3%). The highest FBH incidence was the Regalia anthesis application (32.7%).

**Table 4. The FHB incidence and severity following fungicide treatments at anthesis and post-anthesis, Alburgh, VT 2014.**

| Treatment | Timing | Average FHB severity | Average infected head severity | Incidence of infected heads |
|---|---|---|---|---|
| | | % | % | % |
| Control (water) | All | **2.47** | **10.1** | 18.3 |
| Fusarium | 29-Jun | 7.97 | 28.3 | 24.7 |
| Champ | Anthesis | 6.19 | 24.9 | 19.5 |
| Champ | Post-Anthesis | 3.78 | 13.7 | **18.0** |
| Porsaro | Anthesis | 2.97 | 16.1 | 19.3 |
| Porsaro | Post-Anthesis | 4.59 | 24.6 | 26.2 |
| Regalia | Anthesis | 6.33 | 18.6 | 32.7 |
| Regalia | Post-Anthesis | 3.28 | 27.5 | 24.9 |
| *LSD (0.10)* | | NS | NS | NS |
| *Trial Mean* | | 4.70 | 20.5 | 23.0 |

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

There were significant differences in yield, harvest moisture, and DON level between fungicide+timing treatments (Table 5). All fungicide+timing treatments yielded significantly higher than the control (Figure 2). Both the anthesis and post-anthesis Posaro applications had moisture contents significantly higher than all other treatments in the study. Test weight did not differ significantly by treatment. None of the treatments met industry standards of 48 lbs $bu^{-1}$ for barley. The anthesis applied Prosaro had the lowest DON level (1.06 ppm) and was not significantly different than post-anthesis applied Prosaro and anthesis applied Champ (Figure 3). The DON concentrations of the Regalia treatments did not differ significantly from the control or Fusarium treatments.

**Table 5. The impact application timing and fungicide on barley yield and quality.**

| Treatment | Timing | Yield @ 13.5% moisture | Harvest moisture | Test weight | DON |
|---|---|---|---|---|---|
| | | lbs $ac^{-1}$ | % | lbs $bu^{-1}$ | ppm |
| Control (water) | All | 1643 | 13.6 | 46.6 | 1.74 |
| Fusarium | 29-Jun | 1801 | 12.8* | 46.4 | 1.58 |
| Champ | Anthesis | 2310* | 13.4 | 46.5 | 1.30* |
| Champ | Post-Anthesis | 2253* | **12.5*** | 46.2 | 1.50 |
| Porsaro | Anthesis | 2488* | 14.4 | **47.0** | **1.06*** |
| Porsaro | Post-Anthesis | **2560*** | 14.6 | 46.8 | 1.10* |
| Regalia | Anthesis | 2085 | 13.7 | 46.3 | 1.83 |
| Regalia | Post-Anthesis | 2393* | 13.1* | 46.4 | 1.96 |
| *LSD (0.10)* | | 434 | 0.62 | NS | 0.41 |
| *Trial Mean* | | 2192 | 13.5 | 46.5 | 1.51 |

Values shown in **bold** are of the highest value or top performing.
* Treatments that are not significantly different than the top performing variety in a column are indicated with an asterisk
NS - None of the varieties were significantly different from one another.

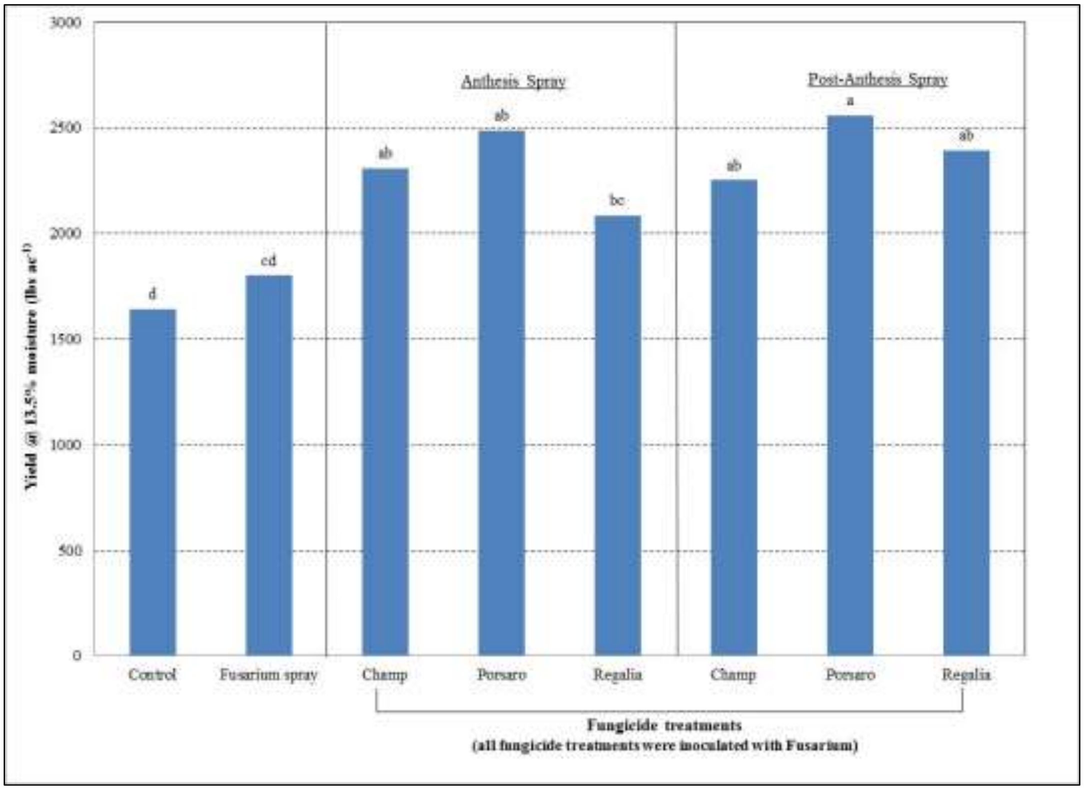


**Figure 2. The impact of application timing and fungicide on barley yield.**
Treatments with the same letter did not differ significantly.

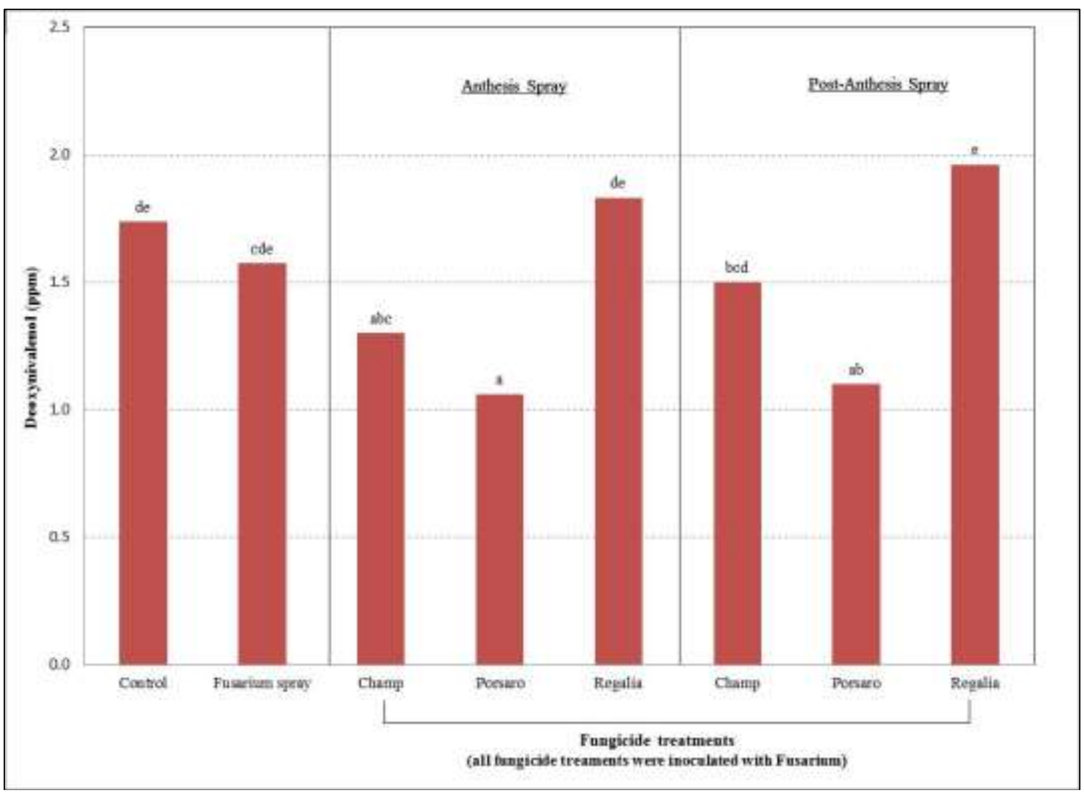


**Figure 3. The impact of application timing and fungicide on DON levels.**
Treatments with the same letter did not differ significantly.

*Impact of Variety*

There were significant differences in the average FHB plot severity and incidence of FHB infection between malting barley varieties (Table 6, Figure 4). Conlon had the lowest average FBH plot severity (1.88%), average infected head severity (18.1%) and the lowest incidence of infected heads (10.0%).

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

| Variety | Average FBH plot severity | Average infected head severity | Incidence of infected heads |
|---|---|---|---|
| | % | % | % |
| Conlon | **1.88*** | **18.1** | **10.0*** |
| Rasmussen | 7.52 | 22.9 | 36.0 |
| *LSD (0.10)* | 2.17 | NS | 6.00 |
| *Trial Mean* | 4.70 | 20.5 | 23.0 |

Values shown in **bold** are of the highest value or top performing.
* Varieties that are not significantly different than the top performing variety in a column are indicated with an asterisk
NS - None of the varieties were significantly different from one another.

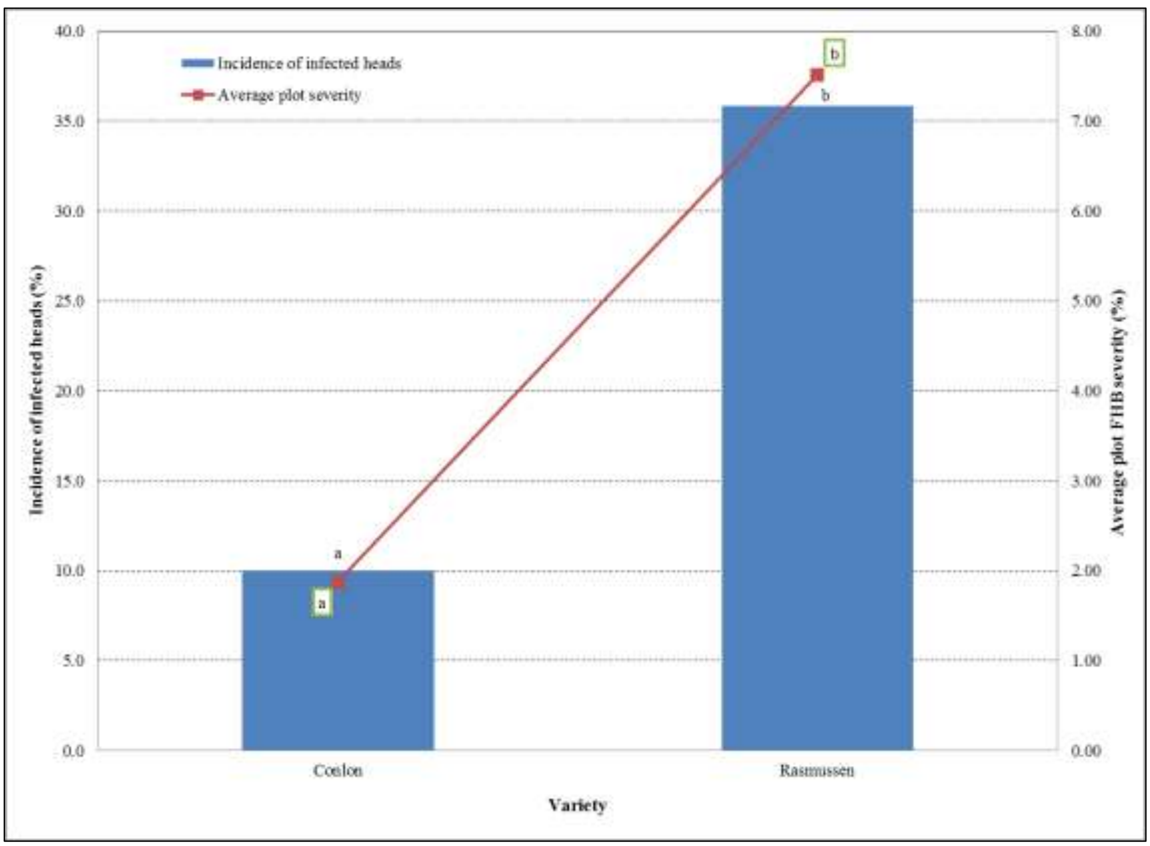


**Figure 4. The impact of barley variety on the incidence of FHB infected heads and the average plot FBH severity.**
Treatments with the same letter did not differ significantly.

The malting barley varieties were significantly different in yield, harvest moisture, test weight, and DON level (Table 7, Figure 5). Rasmussen yielded the highest (2,543 lbs ac$^{-1}$) and Conlon the lowest (1,841 lbs ac$^{-1}$). Conlon had the lowest harvest moisture (13.3%), the highest test weight (46.8 lbs bu$^{-1}$) and the lowest DON level (0.50 ppm).

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

| Variety | Yield @13.5% moisture | Harvest moisture | Test weight | DON |
|---|---|---|---|---|
| | lbs ac$^{-1}$ | % | lbs bu$^{-1}$ | ppm |
| Conlon | 1841 | **13.3*** | **46.8*** | **0.50*** |
| Rasmussen | **2543*** | 13.7 | 46.2 | 2.52 |
| *LSD (0.10)* | 187 | 0.29 | 0.33 | 0.19 |
| *Trial Mean* | 2192 | 13.5 | 46.5 | 1.51 |

Values shown in **bold** are of the highest value or top performing.
* Varieties that are not significantly different than the top performing variety in a column are indicated with an asterisk**.**

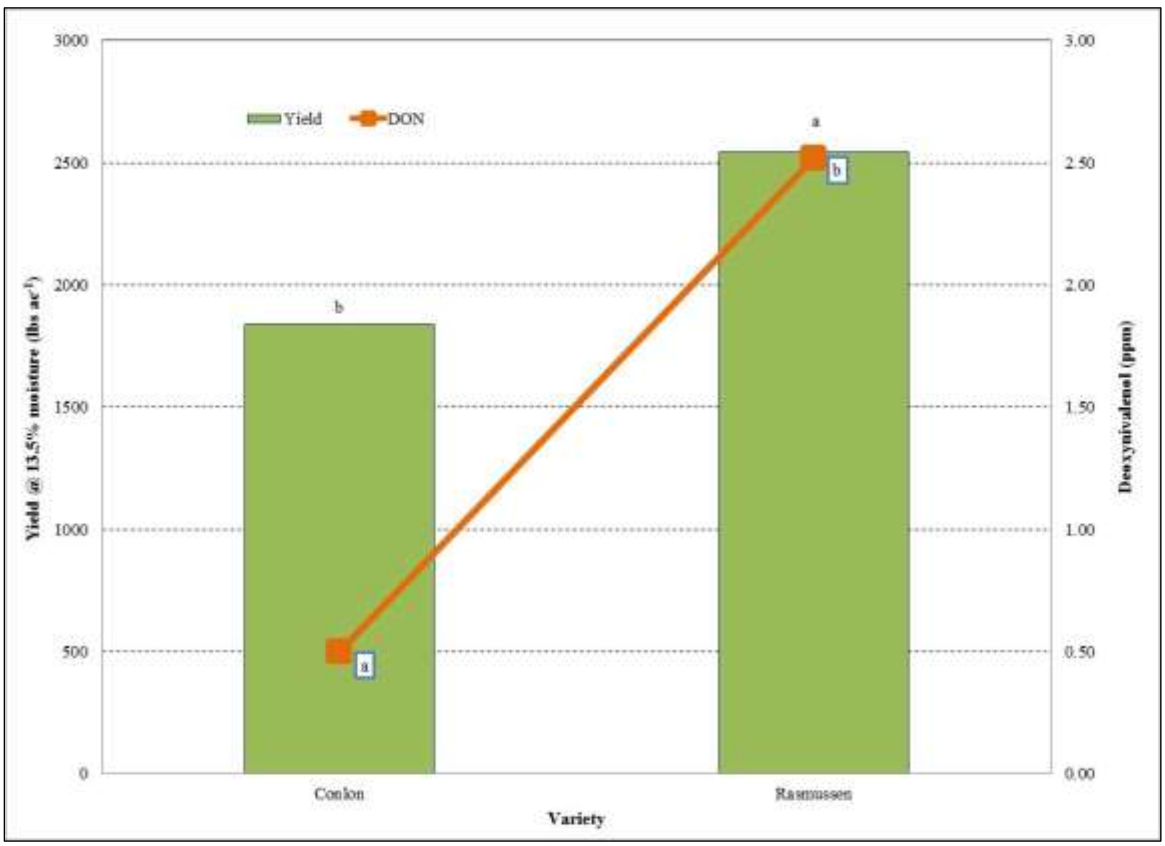


**Figure 5. The impact of malting barley variety on yield and DON level.**
Treatments with the same letter did not differ significantly.

## DISCUSSION

Variety selection is one of the most important disease management strategies that a farmer has at his disposal. In this study Conlon, a moderately resistant variety, had lowest incidence of FHB and DON levels, while Rasmussen, a susceptible variety, had DON levels five times greater (2.52 ppm) than Conlon (0.50 ppm). Even once treated with a fungicide, DON levels in Rasmussen still exceeded the acceptable level of 1 ppm. Hence, this costly application of fungicide would not have been justified. This indicates the importance of selecting resistant cultivars to manage FHB in our region.

The application of a conventional fungicide at anthesis and post-anthesis reduced DON concentrations. Timing of application did not appear to impact efficacy of the fungicide in controlling DON. Interestingly, Champ WG (copper oxide) when applied at anthesis reduced the concentrations of DON similar to Posaro. The post-anthesis application of Champ WG did not significantly reduce DON concentrations compared to the control. This indicates that copper based fungicides sprayed at flowering may have some efficacy for FHB control. This would provide organic farmers with another management tool for FHB control. The Regalia appeared to have no efficacy for FHB control. Regalia is not labeled for FHB.

Treating the barley with the fungicides increased yield over the control. This may indicate that although DON levels were not always reduced the applications may have improved overall plant health. The increased moisture content of Posaro treated plots likely is a result of the reduced FHB infection and healthier grain kernels. Healthier kernels would be slower to dry down.

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 2015.

## ACKNOWLEDGEMENTS

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