**Evaluation of Conventional and Organic Fungicide Applications Plus Cultivar Resistance to Reduce FHB and DON Infection of Barley in Vermont.**

Heather Darby1\* and Hillary Emick1

University of Vermont State and Agricultural College, Burlington, VT 05405

\*Corresponding Author: PH: (802) 524-6501; Email: heather.darby@uvm.edu

**OBJECTIVE**

To evaluate the individual and interactive effects of moderately resistant cultivars and application timings of conventional fungicides and an organic copper fungicide on barley yield and the integrated management of Fusarium head blight (FHB) and deoxynivalenol (DON) in Vermont.

**INTRODUCTION**

Public interest in sourcing local foods has extended into beverages leading to a rapid expansion of the northeast malting industry. This has provided farmers with new market opportunities and many of these markets are interested in purchasing certified organic barley. However, all farmers are struggling to produce barley that is not infected with FHB and DON.Hence integrated management strategies are essential for managing yield and quality losses from FHB. Most farmers in New England have experienced significant crop loss from FHB and some farmers have already stopped growing barley. At present, few farmers are specifically selecting varieties for resistance to FHB and even fewer are combining host resistance with fungicide applications. There has been little to no research conducted to evaluate organic approved fungicides. Other regions have shown that the use of a well-timed fungicide is an important management tool when suppressing FHB in barley production. In Vermont during 2020 we observed the disease and yield impact of cultivar susceptibility, inoculation with *Fusarium graminearum*, and treatment with fungicides (organic and conventional) at two timings.

**MATERIALS AND METHODS**

The trial was conducted in Alburgh, VT in 2020. The soil type was a Benson silt loam soil. The plot size was 5 x 20 ft including seven rows with 7-in spacing. Planting occurred on 9-April, 2020. Main plots were sown with barley at 125 lb ac-1 with a Great Plains grain drill (Salinas, KS). The experiment was set up as a completely randomized block design with a split-plot arrangement, with cultivar as the main plot and the fungicide treatments as subplots, randomized in four replicated blocks. The two spring barley varieties were ‘Robust’ (susceptible to FHB) and ‘Genesis’ (moderately resistant to FHB). Fungicide treatments are shown in Table 1. The first fungicide application (with surfactant at 0.125% V/V) was applied at heading (Feekes growth stage, FGS 10.1). After the fungicide had dried, plots were spray-inoculated with a conidial suspension of *F. graminearum* (40,000 conidia/ ml) to augment the development of FHB. The second fungicide application occurred four days after heading, and inoculated with a conidial suspension of *F. graminearum* (40,000 conidia/ml) after the fungicide had dried. Fungicide and *F. graminearum* treatments were applied with a CO2 backpack sprayer with paired TJ-60 8003vs nozzles mounted at an angle (30o from horizontal) forward and backward, 20-in. apart, pressurized at 30 psi, and calibrated to deliver 20 gal/A. Grain was harvested using an Almaco plot combine (Nevada, IA).. Grain moisture, plot yield, and test weight were recorded. Yield and test weight were adjusted to bushel ac-1 at 13.5% moisture. Analysis of DON content in grain was conducted at the University of Vermont Cereal Grain Testing Laboratory located in Burlington, VT. Treatment means were calculated, subjected to analysis of variance, and separated by Fisher’s protected LSD test (P = 0.05).

**RESULTS AND DISCUSSION**

***Interactions***

There were no variety by fungicide treatment interactions indicating that the varieties responded similarly to the fungicide treatments.

***Impact of Fungicide and Timing***

Harvest metrics are shown in Table 2 and DON concentrations and FHB severity are shown in Table 3. Harvest moisture, test weight, yield,100 kernel weights, and FHB incidence and severity did not differ statistically by treatment. There were significant differences between treatments for DON concentrations (Table 3).

All treatments and timings, including the control and the *Fusarium* inoculated plots, had DON concentrations below the 1 ppm threshold recommended by the FDA. It is important to note that DON results were below the detection minimum of 0.5, which means these results may not be precise. Eight treatments had DON concentrations less than that of the uninoculated control (0.19 ppm). These included Miravis Ace at heading, Miravis Ace followed by Caramba, Miravis Ace followed by Prosaro, Miravis Ace at Feekes 10.3, Miravis Ace post heading, Caramba, and Prosaro. The treatment with the lowest DON concentration was Miravis Ace at heading at 0.03 ppm, which was significantly lower than all ChampION treatments, and the *Fusarium* inoculated plots. The *Fusarium* inoculated plots had the highest DON concentrations as expected, and they were statistically similar to only the three ChampION treatments and the control. All treatments were similar to the control, which is not surprising considering it was a hot and dry June and July, with poor conditions for DON.

There were no significant differences between treatments in the severity of FHB infection and incidence of infection. Caramba applied at heading had the lowest in average FHB severity (7.66%), and Prosaro applied at headed had the lowest FHB incidence (0.02%). The incidence of infected heads refers to the proportion of barley spikes showing any sign of FHB infection compared to the uninfected spikes in that treatment. The average infected head severity refers to the extent to which infected heads are affected by FHB symptoms. The trial average for FHB severity was 13.0% and the average incidence of FHB infection was 0.049%.

***Impact of Variety***

There were significant differences between varieties in harvest moisture, test weight, 100 kernel weights, yield, and DON concentrations (Table 4). There were no significant differences by variety in FHB severity and incidence of FHB infection.

Robust had a significantly lower harvest moisture and higher test weight than Genesis. Both varieties had to be dried down for storage. Genesis yielded 261 lbs ac-1 higher than Robust. The DON concentrations in Genesis (0.08 ppm) were significantly lower than the DON concentration in Robust barley (0.22 ppm), although both were well below the FDA threshold of 1 ppm. FHB severity and incidences were similar between the two varieties.

Higher levels of *Fusarium* infection and resulting DON vomitoxin concentrations in grain are associated with cool and damp weather conditions at the time of grain fill and heading. While early spring weather was slightly cooler than normal, precipitation was below the 30-year average during the entire growing season, and temperatures were warmer than average at grain fill in June and July. These conditions were not conductive for the development of the DON vomitoxin or other fungal pathogens. All fungicide applications reduced DON concentrations compared to the plots that were inoculated with *Fusarium* but not treated with fungicide. Some fungicide applications were statistically similar to the *Fusarium* inoculated plots, but that does not mean they would not be effective in a year with higher DON concentrations. These similarities can likely be attributed to the low DON concentrations overall due to the weather conditions. When fungicide applications in this trial are compared, the results of this trial suggest that Miravis Ave applied at heading, whether combined with other products or not, was the most successful at reducing DON in comparison to an uninoculated control. However, it is important to note that the DON test has a detection range of 0.5 to 5 ppm, and all DON results in this trial were lower than the recommended range for accuracy.

**ACKNOWLEDGEMENT AND DISCLAIMER**

This material is based upon work supported in part by the U.S. Department of Agriculture under agreement No. 59-0206-8-190. This is a cooperative project with the U.S. Wheat & Barley Scab Initiative. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

**Table 1.** Fungicide treatments, active ingredients and rates applied.

|  |  |  |  |
| --- | --- | --- | --- |
| **Fungicide treatments** | **Company** | **Fungicide active ingredient** | **Application**  **rates** |
| Control |  |  | Water |
| *Fusarium graminearum* |  |  | 40,000 spores/ml |
| Prosaro SC® | Bayer CropScience | Prothioconazole + tebuconazole | 6.5 fl oz ac-1 + Induce at 0.125% V/V |
| Caramba® | BASF Ag Products | Metconazole | 14 fl oz ac-1 + Induce at 0.125% V/V |
| Champ ION++ | NuFarm | Copper hydroxide | 1.5 lbs ac-1 |
| Mirvais Ace® | Syngenta | Adepidyn/Pydiflumetofen) + Propiconazole | 13.7 fl oz ac-1  Induce at 0.125% V/V |

**Table 2.** Main effect of fungicide+timing on moisture, test weight, and grain yield at Alburgh, VT, 2020.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Fungicide + Timing Treatment** | **Harvest moisture** | **Test**  **weight** | **Yield at 13.5% moisture** | **100 kernel weight** |
|  | % | lbs bu-1 | lbs ac-1 | g |
| Miravis Ace Post-Heading | 14.20 | 45.7 | 3228 | 4.58 |
| Miravis Ace Feekes 10.3 | 14.13 | 45.3 | 3406 | 4.51 |
| Miravis Ace Heading | 14.09 | 45.3 | 3369 | 4.49 |
| Miravis Ace (Heading) & Caramba (Post) | 15.13 | 45.8 | 3962 | 4.55 |
| Miravis Ace (Heading) & Prosaro (Post) | 14.50 | 45.1 | 3814 | 4.50 |
| Caramba Heading | 14.41 | 44.4 | 3314 | 4.46 |
| ChampION Post-Heading | 13.95 | 46.8 | 3746 | 4.53 |
| ChampION Heading & Post-Heading | 14.13 | 45.8 | 3946 | 4.54 |
| ChampION Heading | 13.96 | 45.3 | 3392 | 4.41 |
| Inoculated *Fusarium* spores | 14.40 | 46.2 | 3656 | 4.65 |
| Prosaro Heading | 13.76 | 45.6 | 3240 | 4.59 |
| Non-sprayed, non-inoculated control | 14.01 | 45.3 | 3281 | 4.40 |
| *LSD (p=0.10)†* | NS‡ | NS | NS | NS |
| *Trial Mean* | 14.2 | 45.6 | 3530 | 4.52 |

† LSD- Least significant difference at p=0.10.

‡NS- Not significant.

**Table 3.** Main effect of fungicide+timing on deoxynivalenol (DON) contamination and FHB severity and incidence at Alburgh, VT, 2020.

|  |  |  |  |
| --- | --- | --- | --- |
| **Fungicide + Timing Treatment** | **DON** | **Average FHB severity** | **Incidence of FHB infected heads** |
|  | ppm | % | % |
| Miravis Ace Post-Heading | 0.11abc | 10.2 | 0.041 |
| Miravis Ace Feekes 10.3 | 0.07ab | 11.8 | 0.062 |
| Miravis Ace Heading | 0.03a | 12.1 | 0.036 |
| Miravis Ace (Heading) & Caramba (Post) | 0.04a | 15.5 | 0.070 |
| Miravis Ace (Heading) & Prosaro (Post) | 0.05a | 11.0 | 0.058 |
| Caramba Heading | 0.14abc | 7.66 | 0.026 |
| ChampION Post-Heading | 0.27cd | 15.3 | 0.054 |
| ChampION Heading & Post-Heading | 0.26cd | 10.9 | 0.073 |
| ChampION Heading | 0.22bcd | 14.9 | 0.050 |
| Inoculated *Fusarium* spores | 0.33d | 14.4 | 0.064 |
| Prosaro Heading | 0.14abc | 14.9 | 0.020 |
| Non-sprayed, non-inoculated control | 0.19abcd | 17.0 | 0.033 |
| *LSD (0.10)* ‡ | 0.153 | NS¥ | NS |
| *Trial Mean* | 0.15 | 13.0 | 0.049 |

†Treatments within a column with the same letter are statistically similar.

‡LSD- Least significant difference.

¥NS- Not significant.

**Table 4.** Main effect of cultivar on deoxynivalenol (DON) concentration, grain yield, and test weight at Alburgh, VT, 2020.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variety** | **Harvest moisture** | **Test weight** | **Yield @13.5% moisture** | **100 kernel weight** | **DON** | **Average FHB severity** | **Incidence of FHB infected heads** |
|  | % | lbs bu-1 | lbs ac-1 | g | ppm | % | % |
| Genesis | 15.4 | 45.1 | **3660** | **4.96** | **0.08** | 13.4 | 0.056 |
| Robust | **13.1** | **46.0** | 3399 | 4.07 | 0.22 | **12.6** | **0.040** |
| *LSD (0.10)* † | 0.33 | 0.55 | 250 | 0.082 | 0.07 | NS‡ | NS |
| *Trial Mean* | 14.2 | 45.6 | 3530 | 4.52 | 0.15 | 13.0 | 0.049 |

†LSD- Least significant difference.

‡NS- Not significant.