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

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**OBJECTIVE**

To evaluate the individual and interactive effects of moderately resistant cultivars and application timings of two organic fungicides 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 2012 we observed the disease and yield impact of cultivar susceptibility, inoculation with *Fusarium graminearum*, and treatment with fungicides (organic and conventional comparison) at two application times.

**MATERIALS AND METHODS**

The trial was conducted in Alburgh, VT during 2021. 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 April 9, 2021. 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 ‘ND 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) on June 16, 2021. 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 ChampION fungicide was the only treatment applied at heading, 4 days after heading, and both at heading and 4 days after heading. 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 bushels ac-1 at 13.5% moisture. Deoxynivalenol (DON) concentrations were analyzed at the McMaster lab at Virginia Tech on an Agilent 6890N / 5975 GC/MS. This method has a detection range of from 0.025ppm – 15ppm. 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 treatments responded similarly regardless of the variety (Table 2).

The growing season was warmer than normal overall, although the month of July was cooler than average. There was a surplus of growing degree days early in the season and a deficit in July, resulting in a season just 36 growing degree days above normal. There was 4.99 inches less precipitation than normal. Low precipitation through heading and flowering stages resulted in low fusarium infection rates and DON concentrations in 2021.

All treatments and timings, including the control and the Fusarium inoculated plots, had average DON concentrations below the 1 ppm threshold recommended by the FDA. However, there were significant differences observed in DON concentrations for the fungicide treatments (Table 2). The highest DON concentrations in the trial were in the Regalia treatment (applied at heading) at 0.925 ppm but statistically similar to the ChampION treatments applied at heading or 4 days after heading. ChampIon applied at heading and again 4 days after heading had lower DON concentrations compared to the other organic fungicide treatments. The conventional fungicide, Miravis had the lowest DON concentration of all fungicide treatments (0.290 ppm) and was the only treatment statistically lower than the *Fusarium* inoculated control. Interestingly, the application of fungicides increased yields significantly compared to the Fusarium inoculated control (Table 4).

The barley varieties performed similarly in DON concentrations but differed significantly in yield and test weight (Table 2). The DON concentrations for both varieties were below the 1 ppm recommendation.

Overall, the growing season was dry and hot leading to low DON concentrations in the trial. The organic fungicides were not as effective as the conventional fungicide applied at heading. However, all fungicides provided enhanced yields compared to the Fusarium inoculated control. Additional research should be conducted to assess the efficacy of multiple applications of copper-based fungicide on FHB.

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**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 |
| Champ ION++ | NuFarm | Copper hydroxide | 1.5 lbs ac-1 |
| Regalia Biofungicide | Morrone Bio Innovations | Reynoutria sachalinensis | 2.0 qts ac-1 |
| Miravis | Syngenta | Pydiflumetofen | 13.7 fl oz ac-1 |

**Table 2.** Statistical significance of treatment effects on DON, test weight, and yield of barley.

|  |  |  |  |
| --- | --- | --- | --- |
| **Source of variation** | **DON** | **Test weight** | **Yield** |
|  |  |  |  |
| Variety | NS**†** | \*\*\* | \*\*\* |
| Fungicide + timing | \*\*\* | NS | \* |
| Variety x fungicide + timing | NS | \*\*\* | NS |
|  |  |  |  |

†statistical significance - \*\*\*, p=0.001; \*\*, p= 0.01; \*, p= 0.05; NS, not significant.

**Table 3.** Main effect of cultivar on deoxynivalenol (DON) concentration, test weight, and grain yield at Alburgh, VT, 2021.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variety** | **DON** | **Test weight** | **Yield** |
|  | **ppm** | **lb bu-1** | **bu ac-1** |
| ND Genesis (moderately resistant) | 0.670 | 47.8 | 89.8 |
| Robust (susceptible) | 0.570 | 44.0 | 76.5 |
| LSD (p=0.05) **†** | NS**‡** | 1.28 | 5.26 |

†LSD; least significant difference at p-value = 0.05.

**‡**NS; no significant difference.

**Table 4.** Main effect of fungicide + timing on deoxynivalenol (DON) contamination and grain yield at Alburgh, VT, 2021.

|  |  |  |  |
| --- | --- | --- | --- |
| **Fungicide + timing** | **DON** | **Test weight** | **Yield** |
|  | **ppm** | **lb bu-1** | **bu ac-1** |
| Non-sprayed, non-inoculated control | 0.165 | 45.4 | 80.3 |
| Inoculated FGS at heading | 0.650 | 44.4 | 72.4 |
| ChampION at heading | 0.800 | 47.4 | 83.8 |
| ChampION 4 days after heading | 0.895 | 44.7 | 85.5 |
| ChampION at heading plus 4 days after heading | 0.630 | 45.6 | 83.8 |
| Regalia Biofungicide at heading | 0.925 | 45.7 | 90.3 |
| Miravis at heading | 0.290 | 46.5 | 86.0 |
| LSD (p=0.05) **†** | 0.190 | NS**‡** | 9.83 |

**†**LSD; least significant difference at p-value = 0.05.

**‡**NS; no significant difference.