SESSION 1:

FHB MANAGEMENT

Co-Chairpersons: Erick DeWolf and
Don Hershman

EFFECTS OF HOST RESISTANCE LEVEL AND INOCULATION TIMINGS ON FUSARIUM HEAD BLIGHT (FHB) DEVELOPMENT AND DEOXYNIVALENOL (DON) PRODUCTION IN THE FIELD IN NORTH DAKOTA.

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INTRODUCTION

Fusarium head blight (FHB), caused primarily by *Fusarium graminearum* (teleomorph: *Gibberella zeae*), is one of the most important diseases of wheat and other cereals worldwide. The disease affects both yield and quality by reducing grain fill and by contaminating grains with various mycotoxins, especially deoxynivalenol (DON). The disease has caused billions of dollars losses to wheat industry in the USA due to multiple disease epidemics (Nganje et al., 2001). FHB is managed primarily through integrating multiple strategies including use of resistant varieties, fungicide applications and cultural practices. A reliable disease forecasting/decision support system is essential to predict FHB epidemic during the season for the regional wheat growers to know if fungicide applications are needed for their crop. Some fungicides with new chemistry such as "PROLINE" have proved effective in FHB management, yield increase, and DON reduction. However, it has also been observed that not all wheat cultivars respond to fungicide applications in similar manner for yield increase (Marcia McMullen, *personal communication*).

Knowledge of level of host resistance, plant growth stage crucial for infection, and relationship between FHB severity and DON production in wheat is important in the development of FHB management strategies including a precise decision support system. Collaborative efforts of epidemiologists located at seven land grant states universities including North Dakota State University have resulted in the development of a FHB forecasting system with more than 80% accuracy, and it has been deployed successfully for the forecasts in ND and other regions of the US. Research work is still underway to make the support system more accurate for forecasting of FHB severity and DON level.

OBJECTIVES

1. Determine the effect of wheat genotypes with different levels of resistance on the development of FHB and DON production

2. Explore the effect of inoculation timings (plant growth stage) on FHB development and DON production

3. Assess the correlation if any between FHB severity and DON level

MATERIALS AND METHODS

Three wheat cultivars Glenn (FHB resistant), Steele-ND (moderately susceptible) and Trooper (susceptible) were planted on May 4 and May 14 and May 9 and 15, in 2007 and 2008, respectively in a field plot located at North Dakota State University Experimental area at Fargo. The experimental design was a split-split plot, with 3 replicates. Planting date (early and late) served as the whole plot; wheat variety (susceptible, moderately susceptible, and moderately resistant) as the sub plot; and inoculation timing [no inoculation, inoculation at early flowering (Feekes GS 10.51), and inoculation at mid flowering (GS10.52) as the sub-sub plot].

Strips of 20 feet wide of wheat cultivar Alsen (moderately FHB resistant) were planted to separate main and subplots from each other serving as buffer. The sub-sub plot size was 20 ´ 10 feet with total 54 plots.

The plots were spray-inoculated with *F. graminearum* spores suspension @ 100,000 spores/ml, with a CO_2 backpack type sprayer equipped with nozzles mounted at 60 degrees angle forward and backward to provide maximum head coverage. Two hundred-twenty-five heads (45 heads/spot) from five spots in each subplot (treatment) were examined for FHB incidence and severity (Stack and McMullen, 1995) at dough stage (Feekes GS 11.2).

Twenty to Forty heads from each subplot depending on the availability, with FHB severity of 0%, 7-21%, 22-50%, 51-79%, and 80-100% were tagged in 2007; whereas 60 heads of each FHB severity category of each cultivar planted on May 9 were tagged in 2008. The heads were hand clipped and kept heads of each category separately for DON analysis and correlation between FHB severity and DON production.

RESULTS

The cultivars differed significantly ($P < 0.05$) in FHB severity but not in disease incidence and DON concentration in both years. Glenn has the lowest level (20.60% and 25.03) in both 2007 and 2008. Trooper has the highest level (28.12%) of FHB severity regardless of planting dates in 2007. Steele-ND has the highest level (46.56%) of disease severity in 2008; however, DON levels differed significantly between the two planting dates. Inoculation timings had significant affect on FHB incidence, severity, and DON concentration in 2007 and 2008 (Table 1 and 2).

All the three disease components: incidence (12.75% and 56.85%), severity (41% and 46.56%), and DON (2.45 ppm and 2.17 ppm) were higher when the cultivars were inoculated at mid flowering stage (GS 10.52) in both years (Table 1 and 2). A positive correlation was observed between FHB severity and DON concentration in all three cultivars Glenn ($r = 0.9865$ and 0.9872), Steele-ND (0.9893 and 0.9354), and Trooper (0.9844 and 0.9928). Overall, Trooper (FHB susceptible) had more DON concentration in all five disease severity categories (range: 1.06-75.68 ppm and 1.10-51.30 ppm) as compared to Steele-ND (1.39-56.86ppm and 0.50-48.50 ppm) and Glenn (0.91-64.63ppm and 0.50-23.4) in 2007 and 2008 (Fig. 1 and 2).

The results indicate that infection at mid flowering growth stage is crucial in FHB incidence, severity, and DON production. Additionally, incorporation of FHB severity level into the FHB disease forecasting system would help in DON level prediction prior to the harvest.

LITERATURE CITED

Nganje, E.W., D. D. Johnson, W. W. Wilson, F. L. Leistritz, D. A. Bangsund, and N. M. Tiapo 2001. Economic impacts of Fusarium Head Blight in wheat and barley: 1998-2000. Agribusiness and Applied Economics Report No. 464.

Stack, R. W., and M. P. McMullen 1995. Extension publication PP-1095, North Dakota State University Extension Service.

Table 1. Effect of wheat cultivars, planting date, and inoculation timings on FHB development and DON production in 2007.

Source	FHB Incidence	FHB Severity	DON
	P>F	*P>F*	*P>F*
Cultivar	0.76	0.03	0.64
Planting date	0.07	0.19	0.007
Inoculation timings	0.001	0.001	0.001

Table 2. Effect of wheat cultivars, planting date, and inoculation timings on FHB development and DON production in 2008.

Source	FHB Incidence	FHB Severity	DON
	P>F	*P>F*	*P>F*
Cultivar	0.25	0.004	0.06
Planting date	0.71	0.19	0.001
Inoculation timings	0.001	0.001	0.001

Fig. 1. Effect of FHB severity level on DON production in three wheat genotypes with different levels of resistance in 2007

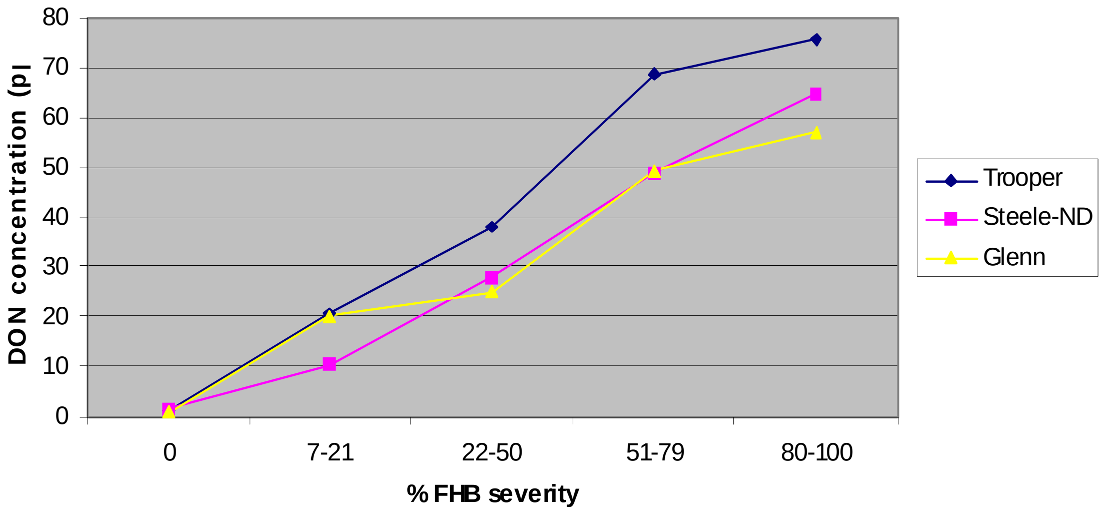
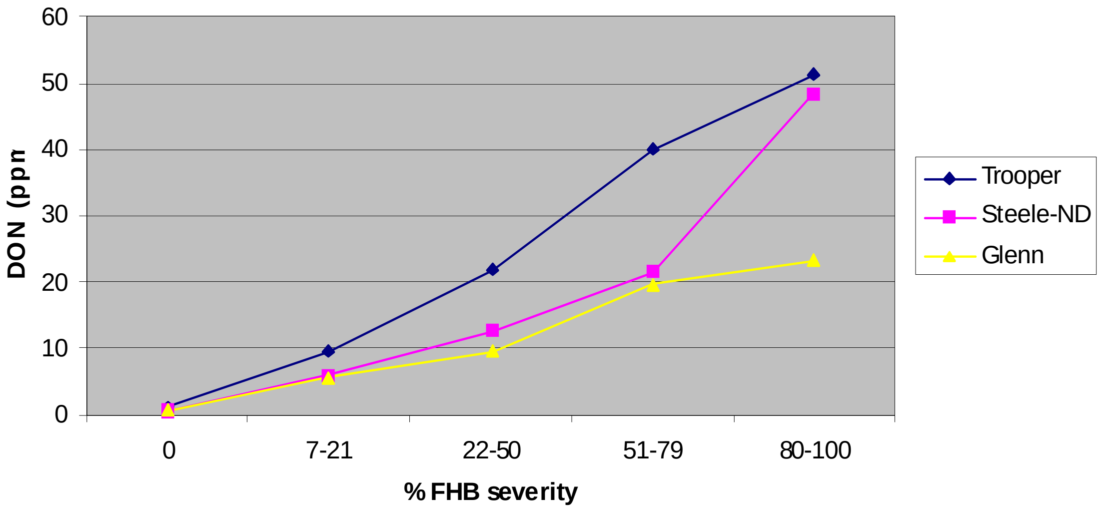


Fig. 2. Effect of FHB severity level on DON production in three wheat genotypes with different levels of resistance in 2008



MICROPLOTS IN COMMERCIAL WHEAT FIELDS FOR QUANTIFYING THE LOCAL CONTRIBUTION OF GIBBERELLA ZEAE FROM NATURAL CORN DEBRIS TO FUSARIUM HEAD BLIGHT AND DEOXYNIVALENOL ACCUMULATION.

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OBJECTIVES

To determine the relative contribution of inoculum of *Gibberella zeae* from naturally over-wintered corn debris to local spike infection and deoxynivalenol (DON) accumulation in commercial wheat fields using a debris microplot experimental system.

INTRODUCTION

A quantitative understanding of the contribution of within-field inoculum sources of *Gibberella zeae* to infection of wheat and barley is important for developing and/or excluding strategies for managing Fusarium head blight (FHB) in individual fields. In another report in these Proceedings, Keller et al. document the contribution of released clonal inoculum from concentrated sources of *G. zeae*-inoculated debris to Fusarium head blight in cereal fields in New York and Virginia. Concentrated clonal inoculum sources contributed significantly to FHB infection at the source, but background populations of *G. zeae* contributed an even greater percentage. The contribution of clonal inocula to spike infection fell off sharply to background levels within 10-20 feet of the concentrated sources, thus validating the use of debris microplots, spaced at 100 ft, as a tool for estimating the contribution of an inoculum source to local spike infection. The next logical question is “What does inoculum from naturally over-wintered cereal debris contribute to FHB infection of local cereal spikes?” To begin to answer this question, we conducted debris microplot experiments in six, geographically diverse, commercial fields of winter wheat in New York in 2008.

MATERIALS AND METHODS

Wheat in each field was planted following harvest of a non-cereal crop such as pea, dry bean, or soybean. Grower cooperators refrained from foliar fungicide use in the experimental portion of each field. Locally over-wintered, natural corn stalks were collected in April from a location close to each wheat field by placing a 33 in. diameter plastic ‘Hoola Hoop’ onto two arbitrarily selected areas in a corn stubble field, and then removing all of the stubble within the hoop and placing it in a paper bag. We also utilized microplots with no corn debris to serve as check plots, and microplots with differing quantities of clone-inoculated corn stalks to calibrate the inoculum contribution from natural corn debris. Ten microplots were set out prior to stem elongation in each wheat field in a randomized design of five treatments and two reps. Microplots were separated by a minimum of 100 ft. Treatments were 1) no debris, 2) natural corn debris, 3) 3 g of clone-inoculated corn stalks, 4) 30 g of clone-inoculated corn stalks, and 5) 300 g of clone-inoculated corn stalks. Inoculum substrates were secured within microplots fashioned of 2 ft high hardware cloth and shaped with a 33 in. diameter ‘Hoola Hoop’, fastened with plastic zip-ties, and secured to the soil with metal ground staples. Wheat spikes above each microplot were scored for FHB at soft dough stage. At grain maturity, all spikes above the 2 ft cages were harvested and dried. Grain was threshed from a subsample of spikes and sent to Virginia Tech for DON analysis. Fifty intact spikes from each microplot were surface-disinfested and plated onto a *Fusarium* selective medium; candidate colonies were confirmed as *G. zeae* on potato dextrose agar and the incidence of spike infection was calculated.

RESULTS AND DISCUSSION

Local release of concentrated clonal inoculum (300 g, approximately the amount of stalk dry weight encountered in a 33 in. diameter area of natural corn debris) resulted in increased spike infection incidence (Table 1) and DON (Table 2) over background levels and in two fields resulted in grain contaminated with DON at levels in excess of 2 ppm (Table 2). Release of naturally-overwintered corn stalks resulted in significantly lower levels of local spike infection than did the concentrated clonal source in five of the six experiments (Table 1), and significantly lower levels of DON in three of the experiments (Table 2). Although natural corn stalks as well as clonal inoculum at one-tenth and one one-hundreth of concentrated strength showed numerical increases in spike infection and DON over background inocula in most locations, these differences were generally not statistically significant. This suggests that the six different local sources of natural corn stalks contributed only small incremental levels of inoculum over that contributed by spores in the atmospheric background on each farm. If within-field sources of *G. zeae* (i.e., infested residues of corn, wheat, or barley) contribute a significant proportion of local inoculum for FHB, then management of those residues should lead to significant reductions in FHB and DON in those fields. These results from six locations in one non-epidemic year in New York suggest that the FHB/DON management benefits of tillage, rotation, or debris treatments in a single field may be limited. This question bears expanded testing under variable environments and production systems. To that end, corn debris microplot experiments are planned for a USWBSI Management Project in commercial cereal fields in Illinois, Missouri, Nebraska, New York, and Virginia in 2009 and 2010.

ACKNOWLEDGEMENTS

This material is based upon work supported by Cornell University Hatch Project NYC153433 and mycotoxin analysis supported by the U.S. Wheat and Barley Scab Research Initiative. We thank Dr. David Schmale and staff at Virginia Tech for quantifying DON in our samples. We are indebted to the New York farmers who allowed us to conduct experiments in their wheat fields.

REFERENCES

Bergstrom, G.C., and Schmale, D.G. III. 2007. Aerobiology of *Gibberella zeae*: Whence come the spores for Fusarium head blight? Pages 70-71 in: Proc. 2007 National Fusarium Head Blight Forum, December 2-4, 2007, Kansas City, Missouri.

Dill-Macky, R. and Jones, R.K. 2000. The effect of previous crop residues and tillage on Fusarium head blight of wheat. Plant Dis. 84:71-76.

Keller, M.D., Schmale, D.G., Waxman, K.D., and Bergstrom, G.C. 2008. Released clones and background inocula of *Gibberella zeae* contributed to Fusarium head blight in winter cereals in New York and Virginia. In: Proc. 2008 National Fusarium Head Blight Forum, December 2-4, 2008, Indianapolis, Indiana.

Table 1. Contribution of corn residue inoculum sources in microplots to infection of local wheat spikes by *Gibberella zeae* in six commercial New York wheat fields in 2008. Each 33 in. diam. caged microplot in a wheat field contained either 1) no corn debris, 2) naturally overwintered corn debris collected in a 33 in. diam. sample from the nearest corn field, or 3) 3, 30, or 300 g dry weight (prior to autoclaving) of corn stalks inoculated with a clone (Gz014) of *Gibberella zeae*.

	Percent of spikes infected by *G. zeae* (St. Dev.)					
Corn residue in plot >	**None**	**Natural**	**Inoc. 3g**	**Inoc. 30g**	**Inoc. 300g**	**LSD (*P*=0.05)**
Cayuga Co. - Aurora	4 (3)	11 (4)	14 (6)	18 (3)	43 (16)	20
Livingston Co. - LeRoy	1 (1)	2 (0)	5 (4)	6 (3)	39 (4)	8
Monroe Co. – Hilton	2 (3)	12 (8)	11 (4)	33 (10)	57 (16)	24
Monroe Co. - Scottsville	0 (0)	0 (0)	2 (0)	5 (7)	40 (17)	21
Seneca Co. - Waterloo	11 (1)	8 (0)	7 (1)	29 (13)	49 (24)	NS
Steuben Co. - Bath	4 (2)	17 (1)	3 (1)	20 (6)	62 (3)	8
Average	**4**	**8**	**7**	**19**	**48**	

Table 2. Contribution of corn residue sources of *Gibberella zeae* in microplots to accumulation of deoxynivalenol in local wheat spikes in six commercial New York wheat fields in 2008. Treatments were the same as in Table 1.

	Deoxynivalenol in grain in ppm (St. Dev.)					
Corn residue in plot >	**None**	**Natural**	**Inoc. 3g**	**Inoc. 30g**	**Inoc. 300g**	**LSD (*P*=0.05)**
Cayuga Co. - Aurora	**0.14** (0.19)	**1.12** (0.98)	**0.65** (0.23)	**0.96** (0.45)	**5.14** (0.43)	1.38
Livingston Co. - LeRoy	**0.30** (0.08)	**0.37** (0.27)	**0.19** (0.26)	**0.32** (0.05)	**2.13** (2.31)	NS
Monroe Co. – Hilton	**0.23** (0.11)	**0.21** (0.08)	**0.16** (0.02)	**0.41** (0.17)	**1.17** (0.66)	NS
Monroe Co. - Scottsville	**0.00** (0.00)	**0.18** (0.06)	**0.08** (0.11)	**0.26** (0.01)	**0.98** (0.06)	0.16
Seneca Co. - Waterloo	**0.11** (0.16)	**0.00** (0.00)	**0.23** (0.32)	**0.29** (0.41)	**0.90** (0.72)	NS
Steuben Co. - Bath	**0.23** (0.00)	**0.63** (0.16)	**0.24** (0.12)	**0.58** (0.37)	**1.88** (0.29)	0.59
Average	**0.17**	**0.42**	**0.26**	**0.47**	**2.03**	

HOST RESISTANCE CORRELATED WITH THE AMOUNT OF DON REDUCTION ACHIEVED WITH FUNGICIDES.

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ABSTRACT

Fusarium head blight (FHB) is a serious disease of wheat. The best controls for FHB are planting of resistant cultivars and application of fungicides to heads. However integrating these strategies may provide additional benefits for small grain producers including reduced disease losses and lower levels of the toxin deoxynivalenol (DON). This research was conducted to determine if resistant cultivars show higher benefits (greater reductions in DON) from fungicide application than susceptible ones. A winter wheat field experiment was established and infested with corn grains colonized by *Fusarium graminearum* applied to the soil surface in three applications about 2 wk apart beginning 4 wk prior to heading (100 g/m^2 total applied). During heading and flowering, plots were sprinkler irrigated (3 min/hr) from 9:00 p.m. until 6:00 a.m. Six winter wheat cultivars were selected based upon their reaction to FHB on a 1-9 scale where 1=resistant and 9=susceptible. The six cultivars, followed by their reactions, were Truman (3), Heyne (4), Roane (5), Karl 92 (6), Overley (9), and Tomahawk (9) and were arranged in a split-plot design with cultivars as main plots and presence or absence of fungicide as sub-plots. There were four replications and sub-plots were 5' by 15'. The fungicide Prosaro (6.5 fl oz/A plus Induce spreader at 0.125%) was applied at the fully headed growth stage using flat-fan nozzles angled forward about 30°. FHB index (% blighted florets) was determined for each sub-plot on May 30, June 2, June 4, and June 9. Sub-plots were harvested with a small-plot combine to determine yields and percentage Fusarium-damaged kernels (FDK). Ground grain samples were sent to the North Dakota State University Veterinary Diagnostic lab for analysis of DON). Severe FHB developed at the site as evidenced by the non-sprayed susceptible cultivar Tomahawk yielding only 7.9 bu/A; however, the non-sprayed moderately resistant cultivar Truman yielded 56.2 bu/A, so yield potential at the site was good. There were significant (*P*=0.0133, 0.0041, 0.0002, respectively) correlations between grain yields, average FHB index, and FDK and the reduction in DON achieved by fungicide application. These correlations indicate that a cultivar's resistance reaction to FHB can help predict the degree of DON reduction by the fungicide Prosaro. More resistant cultivars show higher reductions. Although there were significant correlations between DON reductions from fungicide and three resistance parameters (yields, disease index, FDK), the R^2 values indicate that a cultivar's resistance reaction to FHB explained only 26-48% of the reduction. Clearly, there are other factors that influence DON reduction from fungicide application. However, if these findings are confirmed for naturally occurring FHB epidemics, it may be possible to reduce the impact of the disease and toxin in Kansas by combining fungicides with more resistant cultivars.

MODELING FUSARIUM HEAD BLIGHT AND DON IN BARLEY.

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ABSTRACT

Fusarium head blight (FHB), caused by the fungus *Gibberella zeae*, continues to be a serious problem for barley producers in the U.S. Northern Great Plains. *G. zeae* causes direct economic loss through a reduction in grain yield and also because it produces mycotoxins that can impact the marketability of a crop, e.g. deoxynivalenol (DON). Management of FHB is primarily accomplished with agronomic practices that limit in-field inoculum (e.g. rotation) and through the application of fungicides. The timing of application is critical and therefore a need exists for a risk-advisory system that growers could use to make management decisions. The objective of this research was to develop model(s) for such a system that predicts FHB and/or DON based on weather conditions.

Varieties of regionally adapted barley (both 2- and 6-row types) were grown at multiple locations in the Northern Great Plains during the 2005-8 growing seasons. Crop stage was monitored regularly and no additional inoculum was applied. The incidence and severity of FHB was measured and environmental variables recorded. Correlation analysis and regression techniques were used to identify the variables that were associated with high disease and/or DON events and then predictive models were developed with logistic regression. Models were evaluated based on their sensitivity, specificity, deviance R-square, etc.

Simple weather variables that explained general trends (e.g. mean hourly temperature) tended to have the highest correlation coefficients and were most predictive of high FHB/DON instances. In general, high levels of disease and DON occurred at a location when the mean hourly temperature and relatively humidity were both greater than 22°C and 75%, respectively, for the 10 days prior to full head emergence. A preliminary model was developed that combined these variables. This model had true positive and negative rates of ~90% when tested with the 2005-7 data sets and was able to predict low disease in all of the 2008 South Dakota testing locations. Further analysis of model accuracy is ongoing.

FUNGICIDE CONTROL OF FUSARIUM HEAD BLIGHT ON SOFT RED WINTER WHEAT IN ILLINOIS.

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ABSTRACT

Like many other states in the Midwest, when the conditions are favorable for Fusarium head blight (FHB; caused by *F. graminearum*) in Illinois, losses can be devastating. With the large acreage of corn grown in Illinois, *F. graminearum* inoculum is all around, and it is important for Illinois wheat growers to use integrated management to control FHB and the associated mycotoxin, deoxynivalenol (DON). Because different fungicide products are available for use on wheat, the identification of the most efficacious fungicides that growers can use in an integrated management program for control of FHB and DON is important. Fungicide trials were conducted on winter wheat grown at five locations in Illinois (Brownstown, Carbondale, Dixon Springs, Monmouth, and Urbana). Soft red winter wheat cultivars susceptible to FHB were planted at each location (‘Madison’ – Brownstown, Dixon Springs, and Monmouth; ‘Pioneer 25R78’ – Carbondale; and ‘Cooper’ – Urbana). To increase the likelihood of getting adequate FHB disease pressure, trials were planted into corn stubble, and *F. graminearum* spawn was spread throughout the experimental area. Trials at Carbondale and Urbana were irrigated prior to heading through soft-dough to provide a favorable environment for *F. graminearum* infection and FHB development. In addition to an untreated control, six “core” treatments were applied at Feekes 10.5.1 and evaluated at all locations, which were: Folicur at 4 fl oz; Proline at 5 fl oz; Prosaro at 6.5 fl oz; Caramba at 10 and 14 fl oz; and Topguard at 14 fl oz. At Carbondale, Dixon Springs, and Urbana, Headline at 6 fl oz applied at Feekes 9.0, 10.0, or 10.5 and Proline at 5 fl oz applied at Feekes 10.5 or 5 days after Feekes 10.5.1 were evaluated in addition to the “core” treatments, and at Carbondale and Urbana, Proline 5 fl oz + Headline 6 fl oz applied at Feekes 10.5 was evaluated in addition to the “core” treatments. Overall, the fungicides that provided the most consistent reduction in FHB and DON across the locations were Prosaro at 6.5 fl oz and Caramba at either 10 or 14 fl oz. In general, at the locations where FHB and/or leaf diseases were at moderate to high levels, these fungicides provided significantly greater grain yields compared to the untreated controls. At Carbondale, Headline applied at Feekes 10.5 significantly increased DON levels compared to the untreated control, indicating that strobilurin fungicide applications made to wheat at the Feekes 10.5 growth stage or later could increase the risk of a spike in DON levels.

FUNGICIDES FOR FHB MANAGEMENT: PAST, PRESENT, AND FUTURE.

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ABSTRACT

The best plan for managing Fusarium head blight (FHB), caused by *Fusarium graminearum*, includes an integrative approach that utilizes many different tools. An effective foliar fungicide is one of the crucial tools needed to help make an integrative management plan work successfully. Unfortunately, this “crucial tool” was difficult to identify early on. Results from fungicide tests conducted from the 1970s into the 1990s showed that a few fungicides provided some control of FHB; however, results were often inconsistent, especially with reductions in mycotoxins, such as deoxynivalenol (DON). Few fungicides were registered for use on small grains in the U.S. during this period, and the only one that had good efficacy on FHB (benomyl; Benlate®) was difficult to apply because of its formulation and had limited activity against important leaf diseases that also impacted wheat. Epidemics of FHB in the 1990s in major small grain production regions of the U.S. sparked a multi-state effort to evaluate fungicides for control of FHB. Results of this multi-state effort indicated that the triazole fungicide tebuconazole (Folicur®) was the best of the group tested in reducing both FHB and DON. The process of registering Folicur for use on small grain crops with the U.S. Environmental Protection Agency (EPA) began, but registration was delayed. From 1998 to 2007, Folicur was available for use as a section 18 emergency exemption for wheat growers in some, but not all, states affected by FHB. In 2001, manufacturing of Benlate was discontinued by DuPont. Results of continued, multi-state testing of fungicides indicated that the triazole fungicides prothioconazole (Proline®) and metconazole (Caramba®) provided good control of FHB, and perhaps a better reduction of DON than tebuconazole. In additional fungicide tests, the mixture of tebuconazole + prothioconazole (Prosaro®) was shown to provide better control of FHB and DON than either tebuconazole or prothioconazole alone. In 2007, Proline was registered by the U.S. EPA, and in 2008, Folicur, Caramba, and Prosaro all became registered with the U.S. EPA to control FHB and other wheat diseases. For the first time ever, in the 2009 season, wheat growers in most of the United States will have access to multiple fungicide products that have been proven to reduce FHB and DON. Even though these fungicides have been proven to reduce FHB and DON, there is still much room for improvement. Future fungicide evaluations for control of FHB and DON should include different mixtures of the most efficacious triazole fungicides, mixtures of fungicides with different modes of action, and experimental fungicides.

MULTI-STATE UNIFORM FUNGICIDE TRIALS TO CONTROL FUSARIUM HEAD BLIGHT AND DEOXYNIVALENOL.

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OBJECTIVE

To identify the most efficacious foliar fungicides for control of Fusarium head blight and deoxynivalenol with multi-state uniform fungicide trials.

INTRODUCTION

Foliar fungicide application is one of the key components of an integrated disease management system for Fusarium head blight (FHB; caused by *Fusarium graminearum*) and the associated mycotoxin deoxynivalenol (DON). Although different fungicides are available for use on small grain crops, applying the most efficacious fungicide available is critical in reducing FHB and DON. Reviewing the results of many fungicide trials, Mesterhazy (2003) concluded that tebuconazole was the best active ingredient out of the tested fungicides, but that new fungicides should be developed with better efficacy than tebuconazole. Paul et al. (2008) using a multivariate meta-analysis, reported that prothioconazole, metconazole, and tebuconazole + prothioconazole reduced FHB by an additional 14 to 20% and DON 25 to 29% compared to tebuconazole. Progress has been made in identifying new fungicides with better efficacy against FHB and DON, but additional levels of control could potentially be achieved with new fungicide active ingredients and mixtures. The objective of this study was to identify the most efficacious foliar fungicides for control of FHB and DON.

MATERIALS AND METHODS

The uniform fungicide treatment list was comprised of "core" treatments which were evaluated at nearly all of the locations, and "optional" treatments which were evaluated at fewer locations (Table 1). The core treatments were designed to compare different fungicides applied at Feekes 10.5.1 for control of FHB and DON. The optional treatments were designed for different reasons. The Headline treatments applied at different timings (Feekes 9, 10, or 10.5) were designed to determine the latest that a strobilurin fungicide, such as Headline, could be applied and not increase DON levels. Strobilurin fungicides applied to wheat heads have been reported to increase DON levels compared to untreated heads (Blandino et al., 2006; Mesterhazy et al., 2003), and questions on how late strobilurin fungicides can be applied to wheat and not raise DON levels are unanswered. The Proline + Headline (2 fl oz) treatment was designed to determine if a low rate of Headline could be applied with a triazole to decrease FHB and DON, without a spike in DON due to the strobilurin component. The Proline applied at different timings was designed to help determine the window of application.

These tests were conducted on one hard red winter wheat cultivar and a range of soft red winter wheat cultivars, hard red spring wheat cultivars, and spring barley cultivars in multiple states (Table 2). Each site used different techniques to help increase FHB disease pressure, such as plant susceptible cultivars, plant into corn or small grain stubble, spread *F. graminearum* spawn across plot areas, inoculate heads with *F. graminearum*, and/or irrigate. All fungicides were applied with hand booms that were calibrated to deliver the treatments at recommended pressures and volumes. A non-ionic surfactant at 0.125% v/v was included with all fungicide treatments. Disease ratings were collected at soft dough, and plots were harvested with small plot combines to determine yield. Grain samples were sent to a laboratory to determine DON levels (DON analysis was not completed for samples from all locations at the time this article was written). Each location had a minimum of 3 replications and appropriate statistical designs were used.

RESULTS AND DISCUSSION

FHB index values and DON levels. Two locations, Columbia, MO and Urbana, IL, had the highest FHB index values in the untreated controls which were 32 and 25, respectively. Three locations, Butlerville, IN, Langdon, ND (hard red spring wheat trial), and Monmouth, IL, had FHB index values in the untreated controls that ranged from 5.0 to 8.8. All other locations had FHB index values less than 5.0 in the untreated controls. At the time this article was written, DON analysis on samples from all locations had not been completed; however, in the trials where DON analysis had been completed, DON levels ranged from 0 to 10.68 ppm in untreated controls. Locations with DON levels over 1 ppm in the untreated control occurred at Carbondale, IL, Columbia, MO, Monmouth, IL, and Urbana, IL.

Effect of "core" treatments on FHB index. At the locations with the highest FHB index (Columbia, MO and Urbana, IL), all of the "core" treatments except Topguard significantly reduced the FHB index compared to the untreated control on FHB-susceptible cultivars. At the locations with FHB index values in the untreated controls ranging from 5.0 to 8.8 (Butlerville, IN, Langdon, ND, and Monmouth, IL), results differed at each location. At Butlerville, IN, only Folicur and Prosaro were evaluated, and only Prosaro significantly reduced the FHB index compared to the untreated control. At Langdon, ND on hard red spring wheat, all of the core treatments significantly reduced the FHB index compared to the untreated control, and Folicur, Proline, Prosaro, and Caramba (both rates) significantly reduced the FHB index compared to Topguard. At Monmouth, IL, no significant differences occurred among treatments for FHB index.

Effect of "core" treatments on DON. At the locations with DON levels over 1 ppm (Carbondale, IL, Columbia, MO, Monmouth, IL, and Urbana, IL), results differed at each location. At Carbondale, IL, only Prosaro and Caramba (both rates) significantly reduced DON levels compared to the untreated control. At Columbia, MO and Monmouth, IL, none of the core fungicide treatments significantly reduced DON levels compared to the untreated controls. At Urbana, IL, Folicur, Proline, Prosaro, and Caramba (both rates) significantly reduced DON levels compared to the untreated control. In these trials, even when fungicides did significantly reduce DON levels, DON levels may still have been too high, even from fungicide-treated plots, for elevators to accept the grain; thus, showing the need for more efficacious fungicides and integrated management.

Effect of "core" treatments on grain yield. At nine locations, core fungicide treatments significantly affected yield. These locations were: Dixon Springs, Monmouth, and Urbana, IL; West Lafayette, IN; Columbia, MO; Fargo, ND (hard red spring wheat trial); and Brookings (hard red spring and hard red winter wheat trials) and Watertown (hard red spring wheat trial), SD. At Dixon Springs, IL, plots treated with Proline, Prosaro, Caramba (14 fl oz rate), and Topguard had significantly higher yields than the untreated control, which was at least partially due to leaf rust control at that location. At Monmouth, IL, plots treated with Folicur and Caramba (both rates) had significantly greater yields compared to the untreated control. At Urbana, IL, plots treated with Prosaro, Topguard, and Caramba (both rates) had significantly greater yield than the untreated control due to FHB and leaf rust control. At West Lafayette, IN, only Folicur and Prosaro were tested, and plots treated with Prosaro had significantly greater yield than the untreated control. At Columbia, MO, all of the core treatments significantly improved yield compared to the untreated control on cultivar Roane; however, only Proline, Prosaro, and Caramba (10 fl oz rate) significantly improved yield on cultivar Elkhart. The yield improvement at Columbia was likely due to control of FHB and leaf diseases. At Fargo, ND, all core treatments significantly improved yield compared to the untreated control on the hard red spring wheat trial due to control of FHB and leaf diseases. All core fungicide treatments significantly improved yield compared to the untreated control in the hard red winter wheat trial at Brookings, SD due to leaf disease control. Fungicide treatments did not improve yield of the hard red spring wheat cultivar Briggs at Brookings or Watertown, SD; however, all core treatments improved yield of cultivar Oxen at Brookings, and Folicur and Caramba (both rates) improved yield of cultivar Oxen at Watertown due to control of leaf diseases.

Effect of "optional" treatments. At locations with DON analysis completed and where Headline was applied at Feekes 9, 10, and 10.5 (Carbondale, Dixon Springs, and Urbana, IL; and Columbia, MO), only the Carbondale, IL location showed a significant spike in DON levels compared to the untreated control. At this location, Headline applied at Feekes 10.5 significantly increased the DON level compared to the untreated control (3.62 vs. 1.93 ppm). The Proline + Headline (2 fl oz) treatment did not show an increase in DON levels, but also did not seem to provide any added control of FHB. Proline applied at either Feekes 10.5 or 5 days after the 10.5.1 application timing tended to provide similar results to Proline applied at the Feekes 10.5.1 timing. Additional research should be conducted to confirm that the timing of Proline application between 10.5 and 10.5.1 will not cause different results.

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DISCLAIMER

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the U.S. Department of Agriculture.

REFERENCES

Blandino, M., Minelli, L, and Reyneri, A. 2006. Strategies for the chemical control of Fusarium head blight: effect on yield, alveographic parameters and deoxynivalenol contamination in winter wheat grain. Eur. J. Agron. 25:193-201.

Mesterhazy, A. 2003. Control of Fusarium head blight of wheat by fungicides. Pages 363-380 in: Fusarium Head Blight of Wheat and Barley. K.J. Leonard and W.R. Bushnell, eds. The American Phytopathological Society, St. Paul, MN.

Mesterhazy, A., Bartok, T., and Lamper, C. 2003. Influence of wheat cultivar, species of *Fusarium*, and isolate aggressiveness on the efficacy of fungicides for control of Fusarium head blight. Plant Dis. 87:1107-1115.

Paul, P.A., Lipps, P.E., Hershman, D.E., McMullen, M.P., Draper, M.A., and Madden, L.V. 2008. Efficacy of triazole-based fungicides for Fusarium head blight and deoxynivalenol control in wheat: a multivariate meta-analysis. Phytopathology 98:999-1011.

Table 1. Fungicide treatments evaluated in the 2008 uniform fungicide trials.

Core treatments	Application timing (Feekes)	Active ingredient(s)	No. of locations tested
Untreated			20
Folicur 4 fl oz/A	10.5.1	tebuconazole	20
Proline 5 fl oz/A	10.5.1	prothioconazole	18
Prosaro 6.5 fl oz/A	10.5.1	tebuconazole + prothioconazole	20
Caramba 10 fl oz/A	10.5.1	metconazole	18
Caramba 14 fl oz/A	10.5.1	metconazole	18
Topguard 14 fl oz/A	10.5.1	flutriafol	18
Optional treatments			
Proline 5 fl oz + Headline 2 fl oz	10.5	prothioconazole + pyraclostrobin	4
Headline 6 fl oz	9.0	pyraclostrobin	6
Headline 6 fl oz	10.0	pyraclostrobin	5
Headline 6 fl oz	10.5	pyraclostrobin	5
Proline 5 fl oz	10.5	prothioconazole	4
Proline 5 fl oz	5 days after 10.5.1	prothioconazole	4

Table 2. Small grain classes and cultivars evaluated by each state.

Small grain class	States tested	Cultivars tested
Soft red winter wheat	IL, IN, MO	Cooper, Elkhart, Madison, Pioneer 25R78, Roane
Hard red winter wheat	SD	Wesley
Hard red spring wheat	MT, ND, SD	Alsen, Briggs, Hank, Oxen, Trooper
Spring barley	ND, SD	Robust, Stellar, Tradition

EFFECT OF WINTER WHEAT HARVEST TIMING ON DEOXYNIVALENOL (DON).

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ABSTRACT

When a moderate to severe Fusarium head blight (FHB) epidemic develops, few tools are currently available for managing deoxynivalenol (DON) levels in wheat. At times, growers have been advised to conduct an early harvest of wheat fields with severe FHB, and dry the grain. However, studies of DON concentrations in wheat grain over time have suggested that DON levels decrease during grain-fill and up until normal harvest time. Our objective was to measure DON levels in wheat heads during and after the normal harvest period and under different moisture regimes.

In a misted field nursery in Kinston, North Carolina, we inoculated plots of four wheat cultivars (three moderately resistant to FHB and one susceptible) with 10^5 spores/ml at anthesis. To create two levels of epidemic severity, one block was misted daily for 21 days starting at anthesis, while the other block received no mist during that period. In addition, we manipulated moisture levels in the time window corresponding to a normal or late harvest: within the above-mentioned blocks, plots were misted for 0, 7, or 14 days, starting 1 wk before normal harvest time. All treatment combinations had four replicates. Starting 2 wks before normal harvest time, 30 spikes were chosen randomly from each plot at 7-day intervals for 6 wks. In addition, winter wheat samples were collected from growers' fields in six locations in eastern North Carolina where a natural FHB epidemic occurred in 2008. Collections were made from each field on three dates: around the beginning of normal harvest time, or 7 or 14 days later. On each occasion, all spikes were harvested from two arbitrarily chosen rows in each of four or five replicate "plots" that comprised 10-foot subsections of 40- or 50-foot strips, with each strip six rows wide. All spike samples were threshed and analyzed for DON content.

At Kinston, FHB incidence and severity were significantly greater in the plots misted for 21 days starting at anthesis than in the plots not misted during that period (mean DI 40% and 22%, mean DS 10% and 7%, respectively, $P \leq 0.002$). Mean DON across all sampling dates at Kinston was significantly higher in the block receiving 21 days of mist following inoculation than in the block not misted during that period (5.0 vs. 2.3 ppm, $P < 0.0001$). In the block receiving 21 days of post-anthesis mist, DON was higher 2 wks before normal harvest (the first sampling date) than on any other date. In the block receiving no mist during that period, DON was higher 1 wk before normal harvest (the second sampling date) than on any other date. In the growers' fields, DON levels stayed the same or declined over time. Relevant data on rainfall and temperature are being obtained and analyzed. The objective is to determine whether delay of harvest could be a tool for management of DON in severe FHB epidemics.

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ADVANCES IN THE EPIDEMIOLOGY OF FUSARIUM HEAD BLIGHT AND APPLICATIONS IN PREDICTION MODELS.

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ABSTRACT

Fusarium head blight (FHB) has been an important disease of wheat and barley for more than a century. Both historical accounts and current experience provide some valuable insights into the epidemiology of the disease and suggest weather patterns and crop production practices that generally favor the development of severe FHB epidemics. However, the quantification of many critical aspects of Fusarium biology and details of disease epidemiology has remained elusive for many years. The past decade has brought a tremendous global effort to better understand the epidemiology of this disease, and develop practical tools for management. Critical advancements were made that have helped researchers understand spore dispersal and survival during transport, as well as the processes of infection, colonization and toxin accumulation. These research results have stimulated a new generation of prediction models using both mechanistic and empirical modeling approaches. The focus of the U.S. modeling effort has also been expanded to predict the risk of unacceptable levels of deoxynivalenol (DON) in addition to the severe disease epidemics. Preliminary results indicate that it may be possible to predict the risk of DON greater than 2 ppm with more than 75% accuracy using either mechanistic or empirical modeling approaches. The most accurate predictions are likely to require weather information from anthesis and early stages of kernel development. Further research is needed to maximize the accuracy of models using only pre-flowering weather information and increase the potential use of the models as decision tools for making timely fungicide applications. Candidate models for DON prediction will be tested during the 2009 growing season. If these tests are successful, a model will be released for public deployment as early as 2010.

CULTURAL CONTROL PRACTICES IN THE MANAGEMENT OF FUSARIUM HEAD BLIGHT.

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ABSTRACT

Reduced tillage practices have been adopted worldwide in agriculture over the past twenty-five years. Although the implementation of conservation tillage has been essential to protect vulnerable soils, it has resulted in unanticipated changes in the prevalence of cereal diseases, notably Fusarium head blight (FHB). *Fusarium spp*. survive saprophytically on a range of crop residues including corn, small grain cereals and numerous other grasses. Ascospores released during the late spring and early summer, from perithecia that have developed on crop residues on the soil surface, provide the primary inoculum for FHB epidemics. The link between conservation tillage and FHB is evident if one examines the historical records of FHB in the Upper Midwest. The pattern of epidemics indicate that the only period when FHB was of minor importance in wheat and barley was from the end of World War II until the mid-1980's. This period spans the years from the introduction of tractors with sufficient power to invert the top layer of soil, until the time when the use of the moldboard plough was largely abandoned in favor of tillage systems that provided protection against soil erosion. Further exacerbating the situation in the United States is the increasing corn acreage. Corn production has been promoted by incentives for the increased utilization of corn ethanol as a non-petroleum-based fuel. In Minnesota there has been a significant increase in the acreage of corn in the Red River Valley since the early 1990's. While fungal diseases are generally only of minor importance in corn, *Fusarium* can readily infect the corn plant, inciting stalk and ear rots. Corn breeders have largely prevented the problem of stalk rot by breeding varieties with sufficiently sturdy stems to avoid lodging, even when damaged by a *Fusarium* infection. Ear rot is frequently associated with insect damage to developing corn ears and this damage has been reduced, in part by the introduction of transgenic corn carrying the gene that codes for the *Bacillus thuringiensis* (Bt) toxin. Interestingly, the residues of Bt-corn decompose more slowly than the residues of corn not carrying the Bt gene. Thus, while *Fusarium* poses a limited threat to corn, the increase in corn acreage and the reduced rate of decomposition of Bt-corn undoubtedly exacerbate to the problem of FHB in wheat and barley. We seem unlikely to be able to reduce the threat of FHB epidemics, the attending damage to grain from DON, or the financial devastation to the wheat and barley industries, without addressing the underlying origin of the problem, *Fusarium*-infested crop residues. Given the limitations of our current agricultural practices we are challenged to find ways to reduce the inoculum potential of *Fusarium*-infested residues without removing residues from the soil surface. Host resistance, crop rotation, tillage, residue destruction and chemical and/or biological control, specifically targeting *Fusarium* spp. within the crop residues may play important roles in an integrated approach to the management of FHB. These approaches will work by reducing the initial level of residue colonization, accelerating residue decomposition, and/or reducing the survival or inoculum production potential of the pathogen.

DISCLAIMER

INTEGRATED MANAGEMENT FOR FUSARIUM HEAD BLIGHT OF WINTER WHEAT IN WISCONSIN.

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ABSTRACT

Fusarium head blight (FHB), caused primarily by *Fusarium graminearum*, is a sporadic disease of wheat in Wisconsin, however, when it has occurred, losses have been significant. Furthermore, management guidelines for controlling Fusarium head blight in WI do not exist. As such, it is important to further our understanding and develop a disease management system for wheat in WI that compares the yearly risk of FHB with other diseases known to cause yield loss in the state, especially Powdery mildew and the Septoria-Stagonospora leaf blotch complex. During 2007-2008, foliar fungicide experiments were conducted at the Arlington Agricultural Experiment Station (Arlington, WI) and the West Madison Agricultural Experiment Station (Verona, WI). These experiments examined the effect of wheat variety and fungicide timing on grain yield and development of foliar diseases of winter wheat. The experimental design was a randomized complete block split plot with two soft red winter wheat varieties (Public variety Kaskaskia and Pioneer 25R47) on the whole plot level and six fungicide timings on the subplot. Kaskaskia and P 25R47 are two common winter wheat varieties grown in Wisconsin. Both have mid-ratings for resistance or tolerance to FHB. Subplot treatments included an untreated control, Quilt applied at one of four timings ranging from Feekes 7 to Feekes 10.5, and Proline applied at Feekes 10.5.1. Experimental units measured 3 m by 8 m and plots were planted at a rate of 3.71 million seeds per hectare. Disease assessments were taken prior to first fungicide application in late May and after the last fungicide application in late June. At Arlington, a significant variety by fungicide interaction for the late June disease assessment was found, with applications of foliar fungicides applied at Feekes 7 reducing Powdery mildew in Kaskaskia (20% vs. 0%), while no Powdery mildew was observed in the P 25R47. Interestingly at Arlington, the highest yields were observed with the applications of Proline at Feekes 10.5.1 (6% to 13% higher). At West Madison, disease incidence was higher for diseases that occur at the Feekes 7 growth stage, such as Powdery mildew, compared to Arlington. While grain yield was significantly higher in P 25R47 compared with Kaskaskia at West Madison, yield was not affected by fungicide application. To further quantify the incidence and severity FHB at both locations, a calculation of FHB index was made in the field and the percentage of diseased kernels was assessed after harvest by counting the number of diseased kernels out of a sample of 200 kernels. At Arlington, FHB index values were higher for Kaskaskia (difference of 0.4046), but there was no observed difference at West Madison. Conversely though, the percentage of diseased kernels was higher in P 25R47 compared to Kaskaskia at both locations (29.0% for Kaskaskia and 37.5% for P 25R47 at West Madison, and 29.4% for Kaskaskia and 37.1% for P 25R47 at Arlington). These results indicate that the risk and effects of FHB in WI are complex and often underestimated. Further research to determine the most important risk factors and control options would be beneficial for WI growers.

IMPACT OF EXTENDED PERIODS OF MIST-IRRIGATION ON DEOXYNIVALENOL ACCUMULATION IN *FUSARIUM*-INFECTED WHEAT.

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ABSTRACT

Two field experiments were conducted to examine the effect of extended periods of moisture on the accumulation of deoxynivalenol (DON) in *Fusarium graminearum*-infected wheat. The experiments, conducted in 2007 and 2008, were a split-split-plot design with five replications. Main plots were the duration of mist-irrigation after inoculation [14, 21, 28 and 35 d after inoculation]. Sub-plots were wheat cultivars. Three wheat cultivars used were Alsen (moderately resistant with the resistance derived from Sumai 3), 2375 (moderately susceptible) and Wheaton (susceptible). Sub-sub-plots were *F. graminearum* isolate. Five isolates were used (49-3, 81-2, B45A, B63A, and Butte86ADA-11) in addition to a mock-inoculated water control. The *F. graminearum* isolates used were selected as they differed for relative aggressiveness and DON production capacity. The two-rowed plots (1.8 m long) were inoculated twice, at anthesis and 3 d after anthesis (DAA) with macroconidial inoculum (1 x 10^5 conidia ml^{-1}) at a rate of 30 ml per meter of plot row. The inoculum was applied using a CO_2-powered backpack sprayer. FHB severity was assessed 21 DAA by counting the total and visually symptomatic spikelets in 20 arbitrarily selected heads per plot. Visually scabby kernels (VSK) and DON were determined on grain harvested at maturity. In addition to the assessment of FHB and DON analyses on mature grain, DON was also determined in heads (10 per plot) sampled 0, 7, 11, 14, 21, 28 and 41 DAA. These heads were dried and the entire head ground and analysed for DON. Severity, VSK and the DON for mature grain, were significantly higher ($P - 0.05$), across all isolates, in the susceptible wheat cultivar Wheaton than in the other cultivars examined. FHB severity and VSK were significantly lower ($P = 0.05$) in the treatments receiving the least amount of mist-irrigation (14 d) than for treatments receiving additional mist-irrigation, suggesting that extended periods of moisture promote disease development. DON was however significantly lower ($P = 0.05$) in the 35 d misting treatment than those treatments receiving less water. In the irrigation treatment receiving the longest misting period (35 d) the DON concentration in heads peaked at 14 DAA, and then declined till harvest. However, in the 14, 21 and 28 d mist-irrigation treatments, DON was observed to increase again after the cessation of mist-irrigation, with these increases being most pronounced for the treatments with shorter mist-irrigation periods. DON in head tissues were significantly lower in treatments with increased durations of irrigation in heads sampled 21, 28 and 41 dai, and these difference were greatest in the treatment receiving the longest mist-irrigation period (35 d). The largest reduction in DON observed in the 35 d mist-irrigation treatment was seen in the susceptible wheat cultivar Wheaton. Our results suggest that longer durations of moisture after inoculation, either from mist-irrigation or rainfall, may increase the FHB severity and VSK, although DON concentrations may be concomitantly reduced. Leaching may explain the reduction of DON observed in increased misting duration treatments.

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HOW APPLICATION TECHNOLOGY FOR FHB HAS CHANGED OVER THE DECADE.

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ABSTRACT

The terminology ‘application technology’ has been used to describe methods for applying compounds that reduce the effects of Fusarium head blight (FHB). The primary objective of fungicide application technology research has been to increase the efficacy of fungicides for FHB control. The first research focused on ground application systems and the sprayer components that could effectively improve the efficacy of the fungicides. Two major types of ground application sprayers have been and are being studied. The first type uses hydraulic pressure to generate spray drops and deliver them to the target which on small grains is the grain head or spike. This pressure is either generated by pumps, used by most growers, or pressurized CO_2 which is quite common in the research community because of convenience. The spray solution is pressurized and pushed through a nozzle orifice. The nozzle creates a configuration of small drops and the orientation of the orifice directs the spray toward the target. A second ground system, that is not quite as common, uses an air stream to deliver the drops to the target. This system offers some advantage over the hydraulic system in that the air stream can be adjusted to carry the drops greater distances than the hydraulic system. A hydraulic nozzle typically would be able to push the drops about 50 cm before the drops freefall or are carried by the wind. Aerial application of fungicides has also been researched although not as extensively as ground application. Reports from North Dakota show that in some years about half the fungicide applied to small grains is applied by aerial methods and half by ground methods. The components of these systems that have been studied include drop size, which can be changed by altering pressure and nozzle type, orifice delivery angle, spray volume and spray system travel speed. Several other components have been studied on limited basis because they have not shown to improve currently adopted technologies. These include a rotary atomizer for drop formation, a static electricity system for delivering the drops to the head, and an air induction nozzle that creates a pulsating combination of various size drops. More recently the research field has evolved to include the many classes of adjuvants. Adjuvants work in many different ways and include many types of compounds. One type encapsulates the fungicide molecule to avoid evaporation and movement to areas other than the target.

EFFECTS OF FHB SEVERITY AND CULTIVARS ON DON ACCUMULATION IN WINTER WHEAT.

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ABSTRACT

Fusarium head blight (FHB) of wheat, caused by *Fusarium graminearum*, can cause significant losses resulting from yield reduction, kernel damage, and presence of deoxynivalenol (DON), an important mycotoxin with serious food safety implications. In 2008, an experiment was conducted to identify relationships between visual assessments of FHB and DON. Three winter wheat cultivars (Jagalene, Harry, and 2137) were planted following corn on 27 October 2007. Plots were inoculated with conidia and ascospores of *F. graminearum* (1 x 10^5 spores/ml) at early anthesis and were not irrigated. There also was heavy natural inoculum. Cultivars were arranged in randomized complete blocks with three replications. FHB severity was determined 21 days after inoculation and 20 heads were tagged in each of 13 disease severity categories in each plot: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 70, and 90% in each cultivar. There was a significant positive correlation between FHB severity in the 13 severity categories and DON for all the cultivars: Jagalene ($r = 0.92$, $P = .0001$), Harry ($r = 0.64$, $P = 0.0176$) and 2137 ($r = 0.88$, $P = 0.0001$). However, DON levels were highest in Harry (32 ppm) followed by Jagalene (29 ppm) and 2137 (19 ppm). Similar data were reported in 2007 comparing two cultivars; Harry had a higher level of DON than 2137. This study demonstrated (i) a positive association between DON levels and FHB severity, and (ii) differences among cultivars in the levels of DON they accumulated. For the second year Harry, a moderately resistant cultivar, accumulated higher levels of DON than the susceptible 2137.

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REACTON OF WINTER WHEAT CULTIVARS TO FHB AND DON.

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ABSTRACT

Fusarium head blight (FHB) of wheat, caused by *Fusarium graminearum*, is an important disease due the significant losses resulting from yield reduction, kernel damage, and presence of the mycotoxin deoxynivalenol (DON). One strategy for management of FHB and DON is to plant resistant/tolerant cultivars. In 2008, an experiment was conducted to study the reaction of winter wheat cultivars to FHB and DON. Twelve cultivars (Jagalene, Harry, 2137, Hondo, Alliance, Infinity, Goodstreak, Karl 92, Wahoo, Millennium, Wesley, and Overley) were planted following corn on 27 October 2007 at the University of Nebraska Agricultural Research and Development Center near Mead, NE. Plots were inoculated with conidia and ascospores of *F. graminearum* (1 x 10^5 spores/ml) at early anthesis and were not irrigated. There also was heavy natural inoculum. Experimental design was a randomized complete block with four replications. FHB severity and incidence were determined 21 days after inoculation on 10 heads in each of 10 arbitrarily selected locations in each plot and used to calculate disease index. Plots were harvested with a small plot combine which provided yield data. The percentage of *Fusarium*-damaged kernels (FDK) was measured with an automated single-kernel near-infrared system at the USDA ARS Grain Marketing and Production Research Center in Manhattan, KS. Grain samples from all plots were ground and sent to the North Dakota Veterinary Diagnostic Laboratory at North Dakota State University, Fargo, ND for DON determination. One thousand kernel weight (1000kwt) was determined by counting 1,000 kernels from each plot with an Agriculex ESC-1 electronic seed counter and weighing the sample on an Ohaus electronic balance. Linear correlation analysis was used to determine relationships between FHB index, FDK, DON, yield, 1000kwt, and test weight. Development of severe FHB was favored by excessively wet weather before and during anthesis. Differences among cultivars were highly significant for FHB index ($P < 0.0001$), yield ($P = 0.0068$), 1000kwt ($P < 0.0001$), FDK ($P < 0.0001$), and DON ($P < 0.0001$). Overley had the highest FHB index (64%) followed by Jagalene (35%) and Wesley (30%). Harry had the lowest FHB index (13%) followed by Hondo (14%) and Goodstreak (14%). FHB index in the rest of the cultivars ranged from 17% to 22%. FDK ranged from 21% (2137) to 42% (Harry and Wahoo). Harry had the highest concentration of DON (9.9 ppm) followed by Overely (8.8 ppm) and Jagalene (8.0 ppm). Karl 92 had the lowest concentration of DON (3.7 ppm) followed by Hondo (3.8 ppm) and Alliance (4.1 ppm). DON concentration in the rest of the cultivars ranged from 4.5 ppm to 6.7 ppm. Yield was generally low due to high disease pressure (FHB and Septoria leaf blotch) and ranged from 11 bu/acre (Wahoo) to 20 bu/acre (Karl 92). One thousand kernel weight ranged from 25 g (Wahoo to 31 g (2137).

There was a significant positive correlation between FDK and DON ($r = 0.59$, $P = 0.0442$). There was a significant negative correlation between FDK and yield ($r = -0.74$, $P = 0.0061$), FDK and test weight ($r = -0.64$, $P = 0.0238$), FDK and 1000kwt ($r = -0.84$, $P = 0.0007$), index and test weight ($r = -0.69$, $P = 0.0121$), and DON and test weight ($r = -0.74$, $P = 0.0060$). All other correlations were not significant at $P = 0.05$. This study demonstrated differences among winter wheat cultivars in their reaction to FHB and DON. It was interesting to note that Harry had the lowest FHB index but the highest DON concentration, implying that cultivars with resistance to FHB may be susceptible to DON accumulation. When selecting cultivars, resistance to both FHB and DON accumulation should be considered.

ACKNOWLEDGEMENT AND DISCLAIMER

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DETERMINING POTENTIALS FOR DON ACCUMULATION FROM PRE-HEAD TIMING OF FUNGICIDE APPLICATION ON SPRING WHEAT AND 6-ROWED MALTING BARLEY IN MINNESOTA.

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ABSTRACT

The primary objective of this experiment was to determine whether fungicide-based leaf disease management strategies of wheat and barley promote increased levels of deoxynivalenol (DON) in Fusarium head blight (FHB) diseased grain compared with the nontreated control.

The 2007 wheat and barley experiments included three replicates planted into two years of corn residue on 8 May 07 at the Northwest Research and Outreach Center in Crookston, Minnesota. Wheat and barley cultivars/lines were selected based on their resistance levels to Fusarium head blight (FHB). Wheat cultivars were Reeder (MS), Knudson (MS-MR), and Glenn (MR) while 6-rowed barley cultivars were Tradition, Robust, and M122 (University of Minnesota advanced germplasm line). Six fungicide treatments [nontreated, Folicur (tebuconazole) 4 fl oz/A, Headline (pyraclostrobin) 7 fl oz/A, Quilt (propiconazole & azoxystrobin) 13.88 fl oz/A, Stratego (propiconazole & trifloxystrobin) 13.88 fl oz/A, Tilt (propiconazole) 4 fl oz/A] began on 15 June 07 and were repeated on a weekly basis until 2 July 07 (four weeks) to determine whether fungicide product or application timing influenced DON levels. Barley was harvested 7 August and the wheat on 16 August 07. The tests received neither misting nor pathogen inoculum. Data were analyzed with PROC GLM in SAS using LSD mean comparisons. Log transformations were conducted on DON data. Values reported here are not transformed.

FHB development and associated losses from disease were minimal on cereal crops in the Red River Valley during 2007. Mean FHB index values ranged from 3.15% to 0.05% on wheat and from 0.88% to 0.03% on barley. Yield means ranged from 87.23 bu/A to 58.50 bu/A for wheat and from 109.19 bu/A to 79.53 bu/A for barley. While DON levels were numerically very low, ranging from 0.48 to 0.04 ppm in wheat and from 0.49 to 0.07 ppm in barley, differences were significant between treatments. Reeder had higher DON levels from an application of Quilt (0.42 ppm) or Headline (0.35 ppm) at Feekes growth stage (FGS) 2 compared with the no fungicide control (0.16 ppm; $P<0.0001$). Reeder again responded with elevated DON levels from a FGS 10.0 to 10.4 timing application of Quilt (0.48 ppm) compared with the nontreated control (0.28 ppm; $P<0.0001$). Neither Knudson, nor Glenn responded to fungicide application with significantly increased DON levels. A similar outcome was identified from an application of fungicide on barley. Tradition showed significantly higher DON levels from an application of Quilt (0.41 ppm) at FGS 10 to 10.4 compared with the no fungicide control treatment (0.16 ppm; $P=0.0311$). Neither Robust, nor M122 had significantly elevated DON levels from a fungicide treatment. Increased DON levels in wheat and barley from an early growth stage application of fungicide was unexpected and needs additional study.

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We would like to thank the USDA for funding support; Bayer CropScience, BASF, and Syngenta Crop Protection for providing fungicide; and the University of Minnesota Mycotoxin lab for DON data. This material is based upon work supported by the U.S. Department of Agriculture, under Agreement No. 59-0790-3-080. 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 authors and do not necessarily reflect the view of the U.S. Department of Agriculture.

UNDERSTANDING PRACTICAL OUTCOMES FROM IMPLEMENTING INTEGRATED FHB MANAGEMENT STRATEGIES ON MALTING BARLEY IN MINNESOTA.

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OBJECTIVE

The objective of this two year experiment was to determine grain yield and kernel quality benefits from treating four commercially-available 6-rowed malting barley cultivars and four advanced 6-rowed malting germplasm lines with different Fusarium head blight (FHB) disease management strategies.

INTRODUCTION

This research represents Minnesota's participation in the multi-state, multi-year integrated disease management cooperative research effort which was organized to identify the most practical means for managing FHB across states.

MATERIALS & METHODS

The 2007 experiment included four replicates planted on 9 May 07 into soybean residue near Warren, in northwest Minnesota. Cultivars planted were Drummond, Legacy, Robust, and Tradition while barley germplasm entries were 6B01-2218 (Celebration) and 6B01-2513 [Busch Agricultural Resources, Inc. (BARI)], M122 (University of Minnesota), and ND20448 (North Dakota State University). All entries were exposed to a fungicide treatment (Table 1). Likewise, the 2008 experiments had four replicates of the same entries listed above at field experiment sites near Warren and Mahnomen, Minnesota. The Warren site was planted on 30 April 08 and Mahnomen on 8 May 08. None of these tests received misting or pathogen inoculum. Data from three experiment years (1-2 sites x 2 years) were analyzed using PROC MIXED of SAS. Best linear unbiased estimate or prediction values (BLUEs or BLUPs) were calculated for factors and their interactions. Fungicide and cultivar were considered fixed while environment and its interactions were considered random.

RESULTS & DISCUSSION

FHB development and associated losses from disease were minimal on cereal crops during both production years in the Red River Valley. FHB incidence means were significantly less for germplasm entry (6.48%) compared with cultivar (11.17%; *P*=0.0096), while no differences were detected for FHB severity. FHB indexes were numerically low, but differences were detected. The germplasm index mean was lower than that of cultivar (0.31% vs 0.62%; *P*=0.0296) when averaged over four fungicide treatments. Moreover, germplasm was less than cultivar when disease management Strategy 1 was compared to Strategies 2 through 4 (no fungicide: germplasm 0.43%, cultivar 0.79%, *P*=0.0178; fungicide: germplasm 0.27%, cultivar 0.56%, *P*=0.0397). Environment promoted yield and kernel quality during the second year of our test. Thousand kernel weight (TKW) means were significantly greater during 2008 (39.09 g) compared with 2007 (35.35 g; *P*<0.0001). No differences in TKW were detected between entries or fungicide treatment. Test weight averages were also greater in 2008 (48.64 lb/bu) than 2007 (44.57 lb/bu; *P*<0.0001). No differences in test weight were detected between entries or fungicide treatment. Protein means were slightly increased in germplasm (12.82%) compared with cultivar (12.61%) in the absence of fungicide (*P*=0.0332). A similar response was not detected from entries in the presence of fungicide. Yields were greater in 2008 (110.81 bu/A) compared with 2007 (30.71

bu/A; *P*<0.0001) when saturated soils became a production issue at the test site. Disease management strategy had no effect on yield with one exception. Cultivars responded well to fungicide Strategy 2 resulting in an increase of 5.81 bu/A (*P*=0.0279) over the germplasm mean. Deoxynivalenol and malt quality data for 2008 are not yet available. This information will be critical in determining whether malting barley can once again be produced in Minnesota.

ACKNOWLEDGEMENTS

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DISCLAIMER

Table 1. Disease management strategies tested on four commercially-available 6-rowed malting barley cultivars and four advanced 6-rowed malting barley germplasm lines at a total of three locations during 2007 and 2008 in the Red River Valley.

Trt	Product	Active ingredient	Application Rate*
1	Nontreated control……………	- - -	
2	Folicur………………………...	tebuconazole	4.0 fl oz/A
3	Prosaro………………………...	tebuconazole & prothioconazole	6.5 fl oz/A
4	Prosaro………………………...	tebuconazole & prothioconazole	8.2 fl oz/A

*Treatments 2 through 4 included 0.125% Induce, a nonionic surfactant. Fungicide applications made at Feekes growth stage 10.5 = early heading

UNDERSTANDING PRACTICAL OUTCOMES FROM IMPLEMENTING INTEGRATED FHB MANAGEMENT STRATEGIES ON SPRING WHEAT IN MINNESOTA.

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OBJECTIVE

The objective of this two year experiment was to determine grain yield, kernel quality, and economic benefits from treating a total of 19 hard red spring wheat cultivars with different disease management strategies.

INTRODUCTION

This research represents Minnesota's participation in the multi-state, multi-year integrated disease management cooperative research effort which was organized to identify the most practical means for managing Fusarium head blight (FHB) across states.

MATERIALS AND METHODS

The 2007 experiment included four replicates of 13 cultivars at each of two locations. Planted into soybean residue within commercial fields, a site was located near Oklee in northwest Minnesota and another near Fergus Falls in west central Minnesota. The Oklee site was planted on 27 April 07 and the Fergus Falls site on 2 May 07. Spring wheat cultivars included Ada, Alsen, Banton, Bigg Red, Briggs, Freyr, Glenn, Knudson, Oklee, Samson, Steele-ND, Ulen, and Walworth. Cultivars were treated with one of six disease management strategies (Table 1). The 2008 test included three replicates of 15 cultivars at two commercial field experiment sites. Cultivars included Ada, Alsen, Bigg Red, Breaker, Briggs, Faller, Freyr, Glenn, Hattrick, Knudson, Kuntz, RB07, Samson, Steele-ND, and Tom. Cultivars were treated with the same disease management strategies as before. Second year sites were planted into soybean residue near Fisher and St. Hilaire, Minnesota, both locations situated in northwest Minnesota. The Fisher site was planted on 1 May 08 and St. Hilaire on 5 May 08. No tests received misting or pathogen inoculum. Stand count data were collected at Feekes growth stage 2. Data from four experiment years (2 sites x 2 years) were analyzed using PROC MIXED of SAS. <u>B</u>est <u>l</u>inear <u>u</u>nbiased <u>e</u>stimate or <u>p</u>rediction values (BLUEs or BLUPs) were calculated for factors and their interactions. Fungicide and cultivar were considered fixed while environment and its interactions were considered random.

RESULTS AND DISCUSSION

Data indicated that early stands were not significantly influenced by environment, cultivar, or fungicide. Thousand kernel weight means (TKWs) were significantly greater during 2008 (38.79 g) than 2007 (32.65 g; $P<0.0001$). Cultivars with moderate resistance (MR) to FHB had greater TKWs when compared with moderately susceptible cultivars (MS; $P=0.0154$). Three parameters (yield, test weight, and protein) will be reported separately, but when combined contribute to grain grade which determines disease management strategy economic outcome. Test weight averages were greater in 2008 (64.25 lb/bu) than 2007 (61.94 lb/bu; $P<0.0001$). No significant differences were detected between cultivars grouped by FHB resistance [MR: 63.22 lb/bu, moderately resistant-moderately susceptible (MR-MS): 63.06 lb/bu, MS: 62.96 lb/bu] or fungicide strategy. Protein means were only marginally higher in 2007 (14.23%) compared with 2008 (13.96%; $P=0.0476$). MR-MS cultivars had higher protein (14.47%) than MR (14.03%) or MS (13.87%), while MR and MS were statistically similar. Fungicide strategy did not influence protein.

Yield average was greater in 2008 (91.83 bu/A) compared with 2007 (72.21 bu/A; *P*<0.0001). When grouped by resistance levels, cultivars yielded similarly (MR: 81.33, MR-MS: 80.78, MS: 84.13 bu/A). Fungicide strategy had no effect on yield with one exception. When fungicide Strategy 2 was compared with Strategies 4 and 5, yields from the later were significantly greater. Overall treatment net return mean (economic market benefits derived from combined yield, test weight, and protein minus costs of fungicide and application) was not different between years (2007: $561.63/A, 2008: $585.62/A), and was not significant between cultivar resistance groups or fungicide strategies.

Disease development and associated losses were minimal on spring wheat grown in the Red River Valley during 2007 and 2008. This research demonstrates that prophylactic use of fungicide in environments that do not support disease development does not result in significant yield, kernel quality, or economic benefits when compared to the nontreated control.

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DISCLAIMER

Table 1. Disease management strategies tested on a total of 19 cultivars of hard red spring wheat at four locations during 2007-08 in the Red River Valley.

			Application	
Strategy	Product	Active ingredient	Rate*	Timing**
1	Nontreated control..			
2	Dividend Extreme..	difenoconazole and mefenoxam	3 fl oz/100 lbs	Seed applied pre-plant
3	Headline................	pyraclostrobin	3 fl oz/A	FGS 2
	Folicur/Proline.......	tebuconazole & prothioconazole	3 + 3 fl oz/A	FGS 10.51
4	Dividend Extreme..	difenoconazole & mefenoxam	3 fl oz/100 lbs	Seed applied
	Headline................	pyraclostrobin	3 fl oz/A	FGS 2
	Folicur/Proline.......	tebuconazole & prothioconazole	3 + 3 fl oz/A	FGS 10.51
5	Dividend Extreme..	difenoconazole & mefenoxam	3 fl oz/100 lbs	Seed applied
	Folicur/Proline.......	tebuconazole & prothioconazole	3 + 3 fl oz/A	FGS 10.51
6	Folicur/Proline.......	tebuconazole & prothioconazole	3 + 3 fl oz/A	FGS 10.51

*Treatments 3 through 6 included 0.125% Induce, a nonionic surfactant

** Feekes growth stage (FGS)

2008 RESULTS FROM THE UNIFORM EVALUATION OF BIOLOGICAL AGENTS FOR THE CONTROL OF FUSARIUM HEAD BLIGHT ON WHEAT AND BARLEY.

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OBJECTIVE

To evaluate, using standardized methodology, a set of biological control agents applied alone and in combination with a fungicide for effectiveness in managing Fusarium head blight (FHB) caused by *Fusarium graminearum* and deoxynivalenol (DON) accumulation in wheat and barley across a range of environmental conditions.

INTRODUCTION

Since 2004, experimental microbial agents have been compared for efficacy in controlling FHB and DON as part of the USWBSI-funded program for standardized evaluation of biological control agents. Among them are strains of bacteria *Bacillus subtilis* Trigocor 1448 (da Luz et al., 2003) and *Bacillus* sp. 1BA (Draper et al., 2001). Bacteria in the genus *Bacillus* are attractive candidates for development into commercial biocontrol products because of their ability to produce endospores that are resistant to environmental extremes and their potential to express a number of biocontrol mechanisms (McSpadden Gardener, 2004; Schisler et al., 2004). One strain to recently gain EPA registration is *B. amyloliquefaciens* (=*B. subtilis* var. *amyloliquefaciens*) FZB24 and is the active ingredient in the product Taegro (Novozymes Biologicals). While this strain has been shown to control a wide range of plant pathogens (Krebs et al., 1998), it had not been evaluated previously for control of FHB and DON. Combinations of biological control agents with the fungicide tebuconazole were reported to be more effective in controlling FHB than the microorganisms or the fungicide alone (da Luz et al., 2003; Khan et al., 2004; Jochum et al., 2006). In uniform fungicide trials for FHB control in 2006, the fungicide formulation Prosaro 421 SC (Bayer CropScience) that combines tebuconazole and prothioconazole was demonstrated to be more effective than tebuconazole in enhancing yield and reducing levels of DON (Paul et al., 2006). Therefore, the 2008 uniform biocontrol trials were designed to compare the three *Bacillus* strains, applied alone or in combination with Prosaro, for efficacy in controlling FHB and DON.

MATERIALS AND METHODS

Seven trials were conducted across three states on barley and a range of wheat market classes (Table 1). In each trial, three *Bacillus* biological agents (Table 2) were tested alone or in tank mix with the fungicide Prosaro 421 SC (6.5 fl oz/A). There also was a treatment of Prosaro alone and a non-treated control. A broth culture or formulation of each organism was provided by the originating laboratory/company and sent to the researcher in each location. The pre-application population of each organism strain in the treatment suspensions were determined by the local researcher using dilution plating. All treatment liquids were amended with 0.125% Induce (v/v). In all locations, one application of each treatment was made at early flowering (Feekes 10.51) in 20 gal/acre using CO2-pressurized sprayers (approximately 40 psi) equipped with flat-fan nozzles oriented at a 30° downward angle forward and backward. The size and number of replicate plots varied among trials. Pathogen inoculum was provided in some of the trials in the form of spore suspensions or inoculated corn grain. In addition, mist irrigation systems were utilized at some locations during flowering to stimulate infection. In all trials, FHB incidence (% heads infected per plot), severity (% spikelets infected per diseased head), and index (% plot severity) were determined from at least 40 heads per plot around 3 weeks after anthesis. The incidence of Fusarium-damaged kernels (%FDK), as well as yield of seed and test weight, were determined after harvest. Samples from each plot were sent to the North Dakota State University Veterinary Diagnostic Laboratory, Fargo, ND for analysis of DON content. Analysis of variance was performed on results from each trial separately. Data from all trials were pooled and analyzed together using ProcMixed (SAS). The LSD test was used for means separation.

RESULTS AND DISCUSSION

Dry weather conditions in South Dakota during the flowering period inhibited disease and DON production, while wet weather in Missouri, Nebraska, and North Dakota resulted in higher FHB development. In Missouri, viral diseases barley yellow dwarf and wheat streak mosaic were quite widespread, impacting plant vigor and eventually yield.

None of the *Bacillus* strains applied alone had any effect on disease parameters measured in the field, while Prosaro applied alone or in combination with a biological agent was effective in reducing FHB measures in multiple trials (Tables 3A and 3B). All of the treatments reduced the incidence of Fusarium diseased kernels and most increased test weight in the North Dakota trial (Table 3B). DON was reduced by TrigoCor 1448 in only one trial, while treatments involving Prosaro reduced DON levels in most of the trials (Table 3B). In locations with high disease pressure, however, DON levels in those treatments still exceeded acceptable levels. None of the treatments increased yields over the control except in the North Dakota trial where Prosaro alone and in combination with every biocontrol agent increased plot yields (data not shown).

The collective results from this year's multistate trials indicated no single *Bacillus* strains to be superior in performance across a range of environments or crops. While Prosaro alone reduced the LS mean of incidence of Fusarium diseased kernels (Table 3B), the treatment was not consistently effective across all trials and there was no benefit from combining the biocontrol agents with Prosaro 421 SC. Therefore, it may be desirable to explore combinations of biocontrol agents with less efficacious fungicides, or with moderately resistant varieties as a means to broaden the selection of tactics that can be used to protect florets from Fusarium infection.

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DISCLAIMER

REFERENCES

da Luz, W.C., C.A. Stockwell, and G.C. Bergstrom. 2003. Biological Control of *Fusarium graminearum.* Pages 381-394 in: Fusarium Head Blight of Wheat and Barley. K.J. Leonard and W.R. Bushnell, eds. APS Press.

Draper, M.A., B.H. Bleakley, K.R. Ruden, and N Baye. 2001. Greenhouse screening of biological control agents for suppression of Fusarium head blight. Proceedings of the 2001 National Fusarium Head Blight Forum, pg. 48.

Jochum, C.C., L.E. Osborne and G.Y. Yuen. 2006 Fusarium head blight biological control with Lysobacter enzymogenes strain C3. Biological Control 39:336-344.

Khan, N.I, Shisler, D.A, Boehm, M.J., Lipps, P.E., and Slininger, P.J. 2004. Field testing of antagonists of Fusarium head blight incited by *Gibberella zeae*. Biological Control 29:245-255.

Krebs, B., B. Höding, S. M. Kübart, A. Workie, H. Junge, G. Schmiedeknecht, P. Grosch, H. Bochow, and M. Heves. 1998. Use of *Bacillus subtilis* as biocontrol agent. 1. Activities and characterization of *Bacillus subtilis* strains. J. Plant Dis. Prot. 105:181-197.

McSpadden Gardener, B. B. 2004. Ecology of *Bacillus* and *Paenibacillus* spp. in agricultural systems. Phytopathology 94:1252-1258.

Paul, P., D. Hershman, M. Draper, and L. Madden. 2006. Effect of Fungicides on FHB and DON in Wheat – 2006 Uniform Fungicide Trials. In: Canty, S.M., Clark, A., Van Sanford, D. (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2006 Dec. 10-12; Research Triangle Park, NC. University of Kentucky. pp15-18.

Schisler, D. A., Slininger, P. J., Behle, R. W., and Jackson, M. A. 2004. Formulation of *Bacillus* spp. for biological control of plant diseases. Phytopathology 94:1267-1271.

Table 1. 2008 uniform biological control trial locations, crop cultivars, and researchers

State (location)	Crop market class and cultivar	Researcher and Institution
MO	Soft red winter wheat ‘Roane’	L. Sweets, University of Missouri
MO	Soft red winter wheat ‘Elkhart’	L. Sweets, University of Missouri
NE-1 (Mead)	Hard red winter wheat ‘2137’	C. Jochum & G. Yuen, University of Nebraska
NE-2 (Lincoln)	Hard red winter wheat ‘2137’	C. Jochum & G. Yuen, University of Nebraska
SD	Hard red spring wheat ‘Briggs’	K. Ruden, South Dakota State University
SD	Six-rowed barley ‘Robust’	K. Ruden, South Dakota State University
ND	Hard red spring wheat ‘Howard”	S. Halley, North Dakota St. Univ., Langdon, ND

Table 2. Biological control agents tested in 2008 uniform trials.

Organism	Supplier
Bacillus sp.1BA	Bruce Bleakley, South Dakota State University
Bacillus subtilis TrigoCor 1448	Gary Bergstrom, Cornell University
Taegro *Bacillus amyloliquefaciens* FZB24	Novozymes Biologicals, Inc., Glen Allen, VA

Table 3A. 2008 results across seven uniform biocontrol trials denoted by state and crop

Treatment	MO ‘Roane’	MO ‘Elkhart’	NE-1 2137	NE-2 2137	SD Wheat	SD Barley	ND ‘Howard’	LS mean
INCIDENCE (% heads infected)								
Control	_11_	_40 ab*_	_95 a_	_96_	_6_	_79 a_	_88 a_	**66**
Prosaro	6	29 c	80 c	88	3	63 ab	54 bc	54
1BA	9	40 ab	91 ab	92	11	64 a	78 a	63
1BA + Prosaro	9	31 bc	82 bc	88	5	50 b	54 bc	53
TrigoCor 1448	15	43 a	91 ab	90	8	63 ab	83 a	61
TrigoCor 1448 + Prosaro	9	26 c	88 abc	95	2	59 ab	42 c	52
Taegro	13	35 abc	91 ab	91	9	71 ab	81 a	63
Taegro + Prosaro	10	28 c	89 abc	87	5	50 b	56 b	52
P	NS [§]	0.011	0.0771	NS	NS	0.0598	<.0001	NS
SEVERITY (% spikelets infected)								
Control	23	66	21	27	10	6	21 a	23
Prosaro	20	74	19	21	7	5	12 b	21
1BA	19	66	25	28	14	5	21 a	25
1BA + Prosaro	20	73	20	19	13	5	14 b	21
TrigoCor 1448	29	75	26	22	10	5	21 a	26
TrigoCor 1448 + Prosaro	20	58	19	24	5	5	12 b	19
Taegro	23	66	23	20	10	6	22 a	23
Taegro + Prosaro	25	78	20	20	10	6	13 b	22
P	NS	NS	NS	NS	NS	NS	0.0002	NS

*Means separation (P=0.05) shown only when treatment effect was significant; [§] NS = Not significant.

Table 3B. 2008 results across seven uniform biocontrol trials denoted by state and crop.

Treatment	MO 'Roane'	MO 'Elkhart'	NE - 1 2137	NE - 2 2137	SD Wheat	SD Barley	ND 'Howard'	LS Mean
INDEX (plot severity)								
Control	3	27 ab*	19	27	0.56	5	17 a	15
Prosaro	1	21 bc	15	19	0.35	3	4 b	10
1BA	2	27 ab	23	26	1.47	4	13 a	15
1BA + Prosaro	2	23 bc	16	17	0.77	2	4 b	10
TrigoCor 1448	4	32 a	24	20	0.87	3	15 a	15
TrigoCor 1448 + Prosaro	2	15 c	17	23	0.11	3	2 b	9
Taegro	3	23 bc	21	18	0.84	4	16 a	13
Taegro + Prosaro	2	21 bc	17	18	0.72	3	4 b	9
P	NS	0.04	NS	NS	NS	NS	<0.0001	NS
FDK (%)								
Control	17	29	28	12	2	nd[#]	15 a	16 a
Prosaro	17	25	18	9	3	nd	4 cd	11 c
1BA	16	30	24	15	3	nd	7 bc	14 ab
1BA + Prosaro	14	24	18	9	2	nd	8 b	12 b
TrigoCor 1448	17	31	28	13	4	nd	7 b	15 a
TrigoCor 1448 + Prosaro	12	25	21	11	1	nd	3 d	10 c
Taegro	12	24	27	13	3	nd	6 bc	13 b
Taegro + Prosaro	17	23	20	10	2	nd	4 cd	11 c
P	NS	NS	NS	NS	NS		<0.0001	0.08
DON (ppm)								
Control	1.98 a	12 a	6	4.76 a	1.68 abc	2.63 abc	nd	3
Prosaro	1.23 d	9 bcd	8	2.02 c	1.15 abc	1.88 bc	nd	3
1BA	1.85 ab	12 a	5	3.71 ab	1.95 ab	2.25 abc	nd	3
1BA + Prosaro	1.7 abcd	10 bc	7	2.72 bc	1.33 abc	1.13 c	nd	3
TrigoCor 1448	1.4 bcd	11 ab	8	4.33 ab	2.08 a	3.5 a	nd	3
TrigoCor 1448 + Prosaro	1.83 abc	7 de	9	2.95 bc	0.9 c	1.38 c	nd	3
Taegro	1.85 ab	12 a	8	3.76 ab	1.88 abc	3 ab	nd	3
Taegro + Prosaro	1.35 cd	7 e	7	2.44 bc	1.0 bc	1.65 bc	nd	2
P	0.03	<0.0001	NS	0.08	0.01	0.003		NS
TEST WEIGHT (pounds/bu)								
Control	59	50 c	60	60	53 ab	38	31 d	55
Prosaro	58	54 ab	60	60	55 a	39	35 a	57
1BA	58	52 bc	60	60	52 ab	40	33 bc	56
1BA + Prosaro	59	51 bc	60	60	54 ab	40	35 a	56
TrigoCor1448	57	53 ab	60	60	52 ab	40	32 cd	56
TrigoCor1448 + Prosaro	59	54 ab	60	60	55 ab	40	36 a	57
Taegro	58	50 c	60	60	51 b	39	33 cd	55
Taegro + Prosaro	59	55 a	60	60	55 ab	39	35 ab	57
P	NS	0.0075	NS	NS	0.0132	NS	0.0007	NS

*Means separation (P=0.05) shown only when treatment effect was significant.

#nd = no data; [§]NS = not significant.

ECOLOGY OF *BACILLUS SUBTILIS* ON WHEAT FLORETS IN RELATION TO BIOLOGICAL CONTROL OF FHB/DON.

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ABSTRACT

The TrigoCor strain of *Bacillus subtilis* is one of a handful of biological control agents (BCAs) that show potential in the integrated management of FHB/DON. TrigoCor inhibits the growth of *Fusarium graminearum* in antibiosis assays, and has resulted in excellent and consistent reduction of FHB symptoms and DON accumulation in greenhouse experiments. Like other BCAs tested through the USWBSI, TrigoCor has shown inconsistent biocontrol in the field. The goal of our current USWBSI project is to identify strategies for enhancement of biocontrol by elucidating the ecology of interactions between *Bacillus* and *F. graminearum* on wheat florets under controlled conditions as well as under field conditions. Using TrigoCor as a model BCA, we are describing the dynamics of microbial populations and of *Bacillus*-generated antifungal metabolites relative to biological control. We examined populations of *Bacillus* on wheat florets over critical infection periods in greenhouse and field settings. Using dilution plating, we quantified *Bacillus* populations on wheat heads at 0h, 4-5h, 7d, and 14d after *Bacillus* application. In greenhouse and field experiments, *Bacillus* populations survived at significantly high levels (10^7 and 10^6 per head, respectively) that were consistent throughout the sampling period. The persistence of *Bacillus* on wheat florets suggests this BCA, applied at anthesis, is present in sufficient numbers to protect plants against *Fusarium* infections through flowering and early grain development. In addition to viable bacterial populations, the production and persistence of antifungal metabolites relative to biological control also need to be assessed in controlled and field environments. *Bacillus subtilis* produces several antifungal compounds that appear to contribute significantly to its biocontrol efficacy. Among these compounds are lipopeptides in the fengycin, iturin, and surfactin families, which we have identified through HPLC and mass spectrometry. In a greenhouse experiment, filtered *Bacillus* supernatant enriched for these lipopeptides conferred a 49% reduction in DON and a 30% reduction in FHB severity. The reductions in DON and disease severity were significantly greater than those caused by application of washed *Bacillus* cells, but were less than those caused by a *Bacillus* whole broth culture. These results indicate that lipopeptides may be a critical component in the biocontrol arsenal of *Bacillus*, and suggest that optimization of biocontrol should involve maximizing production of these important compounds under field conditions. We are currently investigating the relative contributions of each family of lipopeptides to biocontrol, and we hope to determine what, if any, threshold levels of these families are necessary for optimal biocontrol. These findings will direct optimization of BCA preparation and application for enhanced biological control.

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RELEASED CLONES AND BACKGROUND INOCULA OF *GIBBERELLA ZEAE* CONTRIBUTED TO FUSARIUM HEAD BLIGHT IN WINTER CEREALS IN NEW YORK AND VIRGINIA.

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ABSTRACT

An increased understanding of the relative contribution of within-field inoculum sources of *Gibberella zeae* to infection of wheat and barley is important for developing and/or excluding strategies for managing Fusarium head blight (FHB). Clonal isolates of *G. zeae* containing rare alleles (relative to background populations) were released in replicated 33 in. diameter circular plots in eight commercial winter cereal fields (seven wheat and one barley) in New York and Virginia over 2007 and 2008. Each field was planted following harvest of a non-cereal crop in order to eliminate potential with-in field sources of *G. zeae*. The eight field environments were categorized as six 'nonepidemic' (all wheat), one 'moderate epidemic' (wheat), and one 'severe epidemic' (barley) based on the incidence of FHB symptoms in non-inoculated plots. Mature wheat spikes were collected at the released inoculum source, at a radius of 10 feet from the source, at a radius of 20 feet from the source, and from non-inoculated (control) sites separated at least 100 feet from a released source. Spikes were observed for symptoms of FHB, disinfested, and plated onto a *Fusarium* selective medium. Nearly 1,500 isolates of *G. zeae* were recovered from spikes among the eight fields. Amplified fragment length polymorphisms (AFLPs) were used to genotype isolates recovered from these spikes and to determine the contribution of released isolates to FHB at various distances from those sources. The clonal isolates released in our field experiments had unique AFLP haplotypes; therefore we were able to observe these clones in a mixed/diverse background population containing numerous AFLP haplotypes. AFLP data demonstrated that locally released clones as well as background inocula contributed to FHB. In 2007, a minority of the recovered isolates in VA (23%; 94/401; moderate epidemic-wheat) and NY (16%; 11/66; nonepidemic-wheat) had AFLP profiles that were identical to our released clones, with the majority of the recovered isolates coming from background sources. Preliminary AFLP data from 2008 experiments showed that 53% (102/191) of the recovered isolates in VA and 66% (180/272) in NY had AFLP profiles that were identical to our released clones, with a considerable percentage coming from background sources. Released clones were recovered at their highest frequencies at the sources, at greatly reduced frequencies at 10 and 20 feet from sources, and only occasionally from non-inoculated sites. Spike infection percentages approached background levels within 10-20 feet of clonal inoculum sources for both fields. FHB symptom incidences, infected spike incidences, and deoxynivalenol (DON) levels (NY fields only) fell off sharply to background levels within 10-20 feet of clonal sources in the fields under study in 2008. Our work has important implications for the management of FHB/DON in wheat and barley. If within-field sources of *G. zeae* (i.e., infested residues of corn, wheat, or barley) contribute a significant proportion of local inoculum for FHB, then management of those residues should lead to significant reductions in FHB and DON in those fields.

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MORE THAN 40 YEARS OF OBSERVATIONS FROM OHIO CONFIRM THE IMPORTANCE OF RELATIVE HUMIDITY AND PRECIPITATION FOR FUSARIUM HEAD BLIGHT EPIDEMICS.

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ABSTRACT

For each of 44 years, an ordinal assessment of FHB in Ohio was performed, based on the general magnitude of disease symptoms, DON in grain, and yield-loss estimates. Each year was given a rating between 0 and 9, and quantitative relationships between the ratings and weather and climatic variables were investigated for the period from 1965 to 2008. Weather data were gathered from weather stations near Wooster, Ohio, and summary variables (such as average RH or ambient air temperature) were calculated for a wide range of time windows and starting times of the windows during the wheat growing season. The windows ranged from 5 to 270 days in duration, beginning at June 20 (around growth stage 11.3) and proceeding back to September 24 of the previous year (about the time of planting). Spearman rank correlation coefficients were calculated to identify the time periods in which weather variables showed significant effects on the FHB rating. This overall protocol is commonly known as 'Window Pane' analysis, which was first introduced by Coakley and colleagues in 1982. Effects of both long-term climatic and short-term weather variables on FHB rating were found. FHB rating and average relative humidity were significantly ($P < 0.01$) correlated for short time windows (e.g., 5-30 days in duration) in both early and late spring, covering the period for spore production, infection, spike colonization and DON production. Average relative humidity for long time windows (e.g., 210 days, beginning at growth stage 11.3) was also significantly correlated with FHB rating, demonstrating the climatic effects of moisture on disease. FHB rating and precipitation were significantly correlated ($P < 0.01$), but only for short time windows in late spring. There was no significant effect of temperature for any time window. In conclusion, results confirm that the impact of FHB on winter wheat in Ohio is dependent, at least in part, on the short- and long-term atmospheric moisture conditions and the short-term amount of precipitation.

RELATIONSHIP BETWEEN FHB AND DON AMONG SRWW CULTIVARS WITH DIFFERENT LEVELS OF TYPE II RESISTANCE.

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ABSTRACT

Deoxynivalenol (DON) is among several mycotoxins produced by *Fusarium* species in infected wheat spikes. DON reduces grain quality and commercial value, leading to price discount and dockage if contamination exceeds 2 ppm. As both a consequence of, and a virulence factor for Fusarium head blight (FHB) development, grain DON content is in general positively correlated with FHB visual estimates, however, this association varies among studies. Difference in cultivar resistance to FHB and DON is one of several factors likely responsible for variation in the functional relationship between FHB and DON. Resistance in the *F. graminearum*/DON/wheat system is a complex trait, with several different types reported (Types I, II, II, IV and V), but not completely characterized. Resistance to fungal spread within the spike, known as type II, is widely adopted in breeding programs, with high levels of Type II generally corresponding to high levels of resistance to DON accumulation. Our goal was to characterize the FHB-DON functional relationship and how it is modified by cultivar resistance. Three experiments were conducted in two years using three soft red winter cultivars with different levels of Type II resistance (Truman, moderately resistant; Hopewell, moderately susceptible; and Cooper, susceptible). At anthesis, plots were spray-inoculated with a 50,000 spores/ml suspension consisting of equal proportions of ascospores and macroconidia. Prior to physiological maturity, FHB head severity was assessed and 20 spikes were tagged in each of 11 severity categories: 0, 1, 2, 3, …10 diseased spikelets per spike. Spikes in each category were hand-harvested and tested for DON. Linear mixed model covariance analysis was used to evaluate the influence of cultivar on the relationship between FHB and DON. In all three experiments, there was a significant linear relationship between FHB and DON, with significantly difference regression slope among the cultivars. For a given level of FHB severity, DON concentration varied among the three cultivars. Hopewell consistently accumulated more DON than the other two cultivars at most of the 11 disease categories, and the DON accumulation rate (FHB-DON regression slope) was significantly higher for Hopewell than for Truman in all three experiments. At various levels of severity, DON differences between Truman and Cooper were smaller than the differences between Hopewell and Truman, but generally, Cooper accumulated more DON than Truman for a similar level of FHB. We found that DON accumulation did not always parallel Type II resistance levels. Hopewell, considered moderate susceptible, accumulated significantly more DON than Cooper, considered susceptible, and based on the FHB-DON regression slope, the rate of DON increase with FHB increase for Cooper was similar to that of Truman, the moderate resistant cultivar, in two of the three experiments. Our data suggest that Type III resistance (resistance to DON accumulation) should be considered separately from Type II resistance when evaluating cultivars and visual estimates of FHB should not be the only standard for evaluating resistance.

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STUDY OF FUNGICIDE EFFECT AND ITS COMBINATION WITH WHEAT CULTIVAR RESISTANCE ON THE RELATIONSHIP BETWEEN FHB AND DON AND THE ACCUMULATION OF DON IN ASYMPTOMATIC WHEAT SPIKES.

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ABSTRACT

Deoxynivalenol (DON) accumulation in *Fusarium graminearum*-infected wheat reduces grain quality, resulting in economic losses for wheat producers. Generally, DON levels are positively correlated with disease intensity, however, in some instances, DON accumulation may exceed 2 ppm (threshold grain buyers adopt when purchasing wheat) in visually disease-free grain. The association between FHB and DON may be influenced by several factors including weather condition, cultivar resistance, fungicide effect on FHB and DON, and pathogen aggressiveness and DON producing ability. Studies have shown that fungicides with similar modes of action may have similar effects on FHB index (visual symptoms) but different effects on DON. This may be due in part to differential effects of the fungicides on grain colonization, and consequently, DON accumulation. Since DON response to fungicide treatment is often confounded by disease response to the fungicide, it is difficult to ascertain the direct effect of fungicide on DON based on mean DON levels from research plots. Our goal was to evaluate fungicide effects on the FHB/DON relationship and the combined effects of fungicide and cultivar on the accumulation of DON in asymptomatic grain. A field experiment was conducted using a split plot design, with six SRWW cultivars of different levels of FHB resistance and three fungicide treatments as whole- and sub-plot factors, respectively. The sub-plot treatments were Folicur (4 fl.oz./A) and Prosaro (6.5 fl.oz./A) applied at anthesis, as well as an untreated check. Plots were spray-inoculated during anthesis with a spore suspension containing 25,000 spores / ml. Fifteen (and in one case ten) asymptomatic spikes were tagged in plots of each treatment combination, and in plots of the susceptible cultivar Cooper, four additional sets of spikes with 1, 2, 3 and 4 diseased spikelets per spike, respectively, were tagged. All tagged spikes were hand-harvested and analyzed for DON. There was a significant linear relationship between FHB and DON for the fungicide treatments and the untreated check. However, the regression slopes were not significantly different among the treatments, suggesting that fungicides did not alter the rate of increase in DON with increase in FHB, relative to the untreated check. The height of the FHB/DON regression line was lower for Prosaro than Folicur, but the difference between the lines was not statistically significant. The DON content of asymptomatic grain ranged from 0.06 to 3.6 ppm. The main effects of fungicide and cultivar on DON (on as square-root transformed scale) in asymptomatic grain were statistically significant. The moderately resistant cultivars (Truman and McCormick) had significantly lower asymptomatic grain DON content that the moderate susceptible cultivars (Hopewell and AGI101). Averaged across cultivars, mean DON in asymptomatic grain was significantly lower in Prosaro-treated plots than in the untreated check.

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MANAGEMENT OF SCAB IN WHEAT USING RESISTANT VARIETIES AND FUNGICIDE.

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ABSTRACT

A study was conducted to assess the effectiveness of fusarium head blight (FHB) resistance, Proline® fungicide, and a combination of both control measures in reducing losses in grain yield and quality. Four soft red winter (SRW) wheat cultivars and eight winter durum wheat varieties were evaluated in a complete block design comprised of three replications and two treatments (varieties with and without fungicide). Experiments were conducted at two locations in Virginia in 2007-2008. Scabby corn seeds were applied to plots at the boot stage, and a spray inoculation using conidia of *Fusarium graminearum* was applied to each variety at 50% flowering in the mist-irrigated test at Blacksburg, VA. Plots in the mist-irrigated test at Mt. Holly, VA were inoculated using only scabby corn seed. Proline was applied at 5.5 oz/ac before flowering time of each variety at both locations. Data were collected for test weight, grain yield, 100 grain weight, and FHB assessment parameters including incidence, severity, index, Fusarium damaged kernels (FDK), and DON concentration. Variance analyses indicated that variety and fungicide treatment had a significant effect on all traits. Treatment and location interaction effects were common except for yield. All of the scab assessment parameters, except for severity, were significantly and highly correlated ($r = 0.4$ to 0.96, $P < 0.001$) with each other. All of the scab parameters, except for FHB severity, had a significant ($r = -0.6$ to -0.9, $P < 0.001$) negative effect on test weight and grain yield. Results of this study indicate that a single Proline fungicide application in eight winter durum varieties significantly reduced FHB incidence (5 varieties), severity (1), index (4), FDK (2) and DON (2). Fungicide application resulted in a significantly higher test weight and yield in two and five durum varieties, respectively. Fungicide application had less effect on FHB infection in moderately resistant versus susceptible winter durum wheat varieties. Non-treated resistant durum varieties, such as VA05WD-12 and VA05WD-16, had less infection than treated susceptible varieties. Four of the non-treated durum varieties had higher test weight and one had higher yields than one of the treated susceptible durum varieties.

The fungicide treatment had less effect on FHB in the moderately resistant SRW wheat versus durum wheat varieties. Only the susceptible SRW cultivar Coker 9835 benefited from the fungicide treatment, which resulted in a significant reduction in scab infection and development and higher test weights and grain yields. FHB resistance in the SRW wheat cultivars was greater than in the winter durum varieties at reducing scab infection and development and losses in grain yield and quality. Results of this study indicate that utilization of SRW and winter durum wheat varieties having moderate scab resistance provides a baseline of protection against FHB that is equal to or better than fungicide application to cultivars having little or no FHB resistance. Nevertheless, fungicide application is beneficial and critical under severe FHB epidemics especially when susceptible cultivars are grown.

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INFECTION TIMING AND MOISTURE DURATION EFFECTS ON FHB AND DON DEVELOPMENT IN SPRING WHEAT AND DURUM, ND.

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ABSTRACT

We continue to investigate how moisture duration and growth stage at inoculation affect Fusarium head blight (FHB) development and DON production in hard red spring wheat and durum wheat. FHB susceptible and more resistant cultivars of hard red spring wheat and durum wheat were grown in the greenhouse. At one of four growth stages (Feekes 10.5 = full head emergence, 10.51 = early flowering, 10.54 = kernel watery ripe, or 11.2 = early soft dough), grain heads were inoculated with spores of a mix of isolates of *Fusarium graminearum* (20,000 spores/ml; 20 ml per pot) and subsequently placed under one of three intermittent misting treatments. The misting treatments were 1) two days in an enclosed mist chamber with intermittent mist for 30 seconds for every 5 minutes, 2) misting treatment one followed by an additional 3 days of misting on the greenhouse bench, under an overhead RainBird sprinkler system, misting for 15 minutes for four times per night, or 3) misting treatment one followed by 8 days under the bench misting system described for misting treatment two. Each combination of growth stage treatment plus misting treatment was replicated six to eight times per cultivar/trial and each trial was done three times. FHB incidence, head severity and index ([incidence x head severity])/100 were determined 14 to 21 days after inoculation. DON, 15ADON, and 3ADON values were determined on grain that was hand-threshed at maturity, ground, and then analyzed by the NDSU Toxicology Lab using gas chromatography and electron capture techniques. Results indicated that both the susceptible durum (Monroe) and the susceptible spring wheat (Trooper) had considerably more FHB and DON than their more resistant counterparts (Divide durum and Glenn spring wheat), for most inoculation timings and moisture treatments. The 5 day and 10 day misting treatments resulted in greater disease and DON than the 2 day duration, indicating duration of moisture does affect disease severity and DON, similar to previous findings. The two durum cultivars had a long window of vulnerability to infection, from flowering (Feekes 10.51) through early soft dough stage (Feekes 11.2), while severe infection occurred primarily at one growth stage in spring wheat - at kernel watery ripe (Feekes 10.54) in the susceptible spring wheat, and at flowering (Feekes 10.51) in Glenn, the more resistant cultivar. Inoculations at full head emergence but before flowering (Feekes 10.5) in both grain classes resulted in no or very low FHB and DON. 15ADON was only detected in one experiment, and nivalenol was not detected. 3ADON detection also was limited and occurred almost exclusively in the susceptible cultivars when misting durations were 10 days and only when the DON levels were very high (average > 25 ppm).

PHYSIOLOGIC PROFILING AND CARBON SOURCE UTILIZATION OF FOUR *BACILLUS* STRAINS USED AS BIOLOGICAL CONTROL AGENTS OF FHB.

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ABSTRACT

Understanding use of plant nutrients and specific carbon sources by plant pathogens such as *Fusarium graminearum* is important for designing biological control methods to control the fungus. It is important in biological control agent (BCA) spray application to avoid adding carbon sources to the spray mix that would stimulate *F. graminearum.* Four strains of *Bacillus amyloliquefaciens* (designated 1D3, 1BC, 1BE, and 1BA), used as biocontrol agents antagonizing FHB, have not been previously assayed for xylanase and carboxymethylcellulase (CMCase) activity. Plate assays were conducted with two CMC-containing media and one xylan-containing medium, with incubation at both 27 Celsius and 45 Celsius. Medium CMC-1 had a high C/N ratio and yeast extract as nitrogen source. Medium CMC-2 had a much lower C/N ratio and ammonium sulfate as nitrogen source. Ratios of zone of clearance diameter to colony diameter were compared. On CMC-1, the ratio for strain 1BA was about the same at both temperatures, but for the other three strains, ratios were about twice as large at the higher temperature, with values up to 4.7. On CMC-2, the ratio value of 4.6 for strain 1BA was about 1.4 times as large at the higher temperature; while ratios for the other three strains were approximately the same at both temperatures. At 27 Celsius, ratios for strains 1BC and 1BE were twice as large on CMC-2 as on CMC-1. For xylanase activity at 27 Celsius, strain 1D3 had the lowest ratio of 2.8, while all other strains had ratios near or above 4. At 45 Celsius, no zones of clearance were present for any strain besides that below the colonies. The xylanase activity of the strains appeared to be much more temperature sensitive than the CMCase activity. Ability of the BCAs to use CMC and xylan may correlate with their originally being isolated from wheat residues. BioLog GEN III microplates were also used to determine which carbon sources each strain used; and which substances were inhibitory to each strain. The strains all shared ability to grow well on one or more organic acids. Two of the strains (1BA and 1BC) grew well on pectin. Analysis of stimulatory and inhibitory substances affecting growth of these bacilli is important for developing their use as biocontrol agents of FHB. (Parts of the poster were presented at the Society for Industrial Microbiology Annual Meeting and Exhibition, August 10-14, San Diego, CA).

USE OF MOST PROBABLE NUMBER AND PCR METHODS TO ESTIMATE POPULATIONS OF *BACILLUS* STRAIN 1BA APPLIED TO WHEAT AND BARLEY FOR BIOLOGICAL CONTROL OF FHB.

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ABSTRACT

After spray application of biological control agents (BCAs) onto grain heads for control of FHB, it is important to understand how populations of the BCAs change over time. We are focusing on a *Bacillus* 1BA strain for use as a BCA. In the 2008 uniform biocontrol trials in Brookings, using most probable number methodology to assay BCA populations, control plots that did not receive spray application of BCAs had very low numbers, in the hundreds per gram fresh plant mass, showing there is a small number of native bacteria that can tolerate the high salt and temperature conditions used in recovering and counting BCA bacteria from grain heads. Bacterial numbers recovered from barley were low in both control and treated plots, again indicating that 1BA does not grow well on barley heads.

In the Brookings trial, endospore numbers (in the heat-pasteurized count) did not increase dramatically until about day 16 after spraying. There was probably a large increase in vegetative cells between days 9 and 16 that was not detected in the sampling dates used. Results from 2006 and 2007 showed an increase in numbers around day 10 that was much greater than the one for 2008. Inclusion of Prosaro with Induce and *Bacillus* 1BA resulted in an early increase of 1BA numbers (around day 3) followed by a decline and no futher increase in numbers. This apparent effect of Prosaro in causing a more rapid increase in 1BA numbers on wheat heads was also noted in 2007 field data.

In Brookings, plots, wheat heads that had been sprayed with 1BA mutant strains (spontaneous mutant having rifampicin resistance) were processed for extraction of bacterial DNA, and using primers specific for the surfactin gene, PCR was carried out on the extract to see if there was evidence of surfactin genes on the grain heads. PCR product for surfactin was detected on inoculated wheat heads, but not on control (uninoculated) heads. This shows that PCR methodology is able to detect presence of the surfactin-producing BCAs on treated grain heads. PCR analyses of grain heads will continue in FY09, and primer sets for the lipopeptide iturin will also be used in addition to the surfactin primers.

THE INFLUENCE OF FUNGICIDES FOLIAR TREATMENTS ON THE WHEAT YIELD AND QUALITY.

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Wheat crops are damaged by numerous diseases which caused quantitative and especially qualitative yield losses in Transylvania conditions.The complex of foliar diseases : powdery mildew (*Blumeria graminis* f. sp. *trtrici),* leaf and glume blotch (*Septoria trtrici* and *Stagonospora nodorum*), rusts (*Puccinia striiformis, Puccinia recondita and Puccinia graminis*) and tan spot (*Pyrenophora tritici – repentis*) as well as head blight (*Fusarium* spp.) and ears blackening (*Alternaria* and *Cladosporium*) are the most frequent in wheat crops. Yield losses reaching 30% from yield value depend on climatic conditions and wheat cultivar.

METHODOLOGY

The effect of fungicide foliar treatments and winter wheat was studied at ARDS Turda during two years. It was organized by factorial trials after block split type with 3 treatments variants: untreated (T_0), 1 Treatment (T_1) applied at through early flag leaf emergence (ZGS38) and 2 treatments (T_2) applied through early flag leaf emergence (ZGS38) and in the end of flowering (ZGS73). The fungicides used contain: spyroxamine 250 g/l+tebuconazole 167g/l+triadimenole 43g/l at dose 0,6 l/ha, for the first treatment, respectively prothioconazole 125g/l+ tebuconazole 125g/l at dose 0,9 l/ha for the second treatment. In the field, attack degree for main diseases (%) and yield (kg/ha) and in the laboratory, baking parameters protein and wet gluten content (%) were determined. It also evaluated, thousand kernels weight (TKW), volumetric weight and percentage of diseased kernels.

RESULTS

The weather conditions from April, May, June months of 2 years is characterized by high temperature associated with weather deficit, were not very favorable of the diseases occurrence, it know that is essentially weather- dependent. Foliar diseases: powdery mildew, tan spot, leaf blotch and brown rust and ears diseases: Fusarium head blight (FHB) were presented in wheat crops. By applying of one single fungicide treatment, attacked leaf area by foliar diseases was significantly reduced in average with 50% and quite more at Turda 2000 and Apullum cultivars. Applying of 2 treatments diminished substantially diseased leaf area (3,8%) and the FHB attack (2,6%), with positively effect on the yield capacity. Applying one foliar treatment increases yield with 5,4-13,8 %, average being 9,5% and for two treatments with 14,0-20,1%, average being 16,4 %, in the two ears. For Turda 95 and Dumbrava wheat cultivars, the highest yield by 6436 kg/ha respectively 6462 were registered.(Fig 1.)

Between spikes and disesased kernels a positive and semnifictive correlation exists, defined by equation: $y=1{,}0447x+5{,}7327$; $R^2 = 0{,}6268$*.(Fig.2.)

Besides substantially significant yield gains were really improved the quality in term baking due to gluten content. Applying two treatments with fungicides determined an evident increase reach up to 30,7 % of the wet gluten and to 11,7% of the protein conten (Fig.3). Tested fungicides were presented a good efficacy in controlling of foliar and ear disease, remarked Soprano (0,75l/ha), Tango Super(1.0l/ha), Artea (0,4l/ha), Caramba(1,0l/ha), Falcon (0,7l/ha), Amistar Extra (0,5l/ha), Nativo 0,8 (l/ha), Prosaro (0,9l/ha).

CONCLUSIONS

Realizing of wheat performed and quality yield could not possible without a corresponding protection against foliar and ear diseases in humide and semi-humide area, like Transilvania-Romania.

REFERENCES

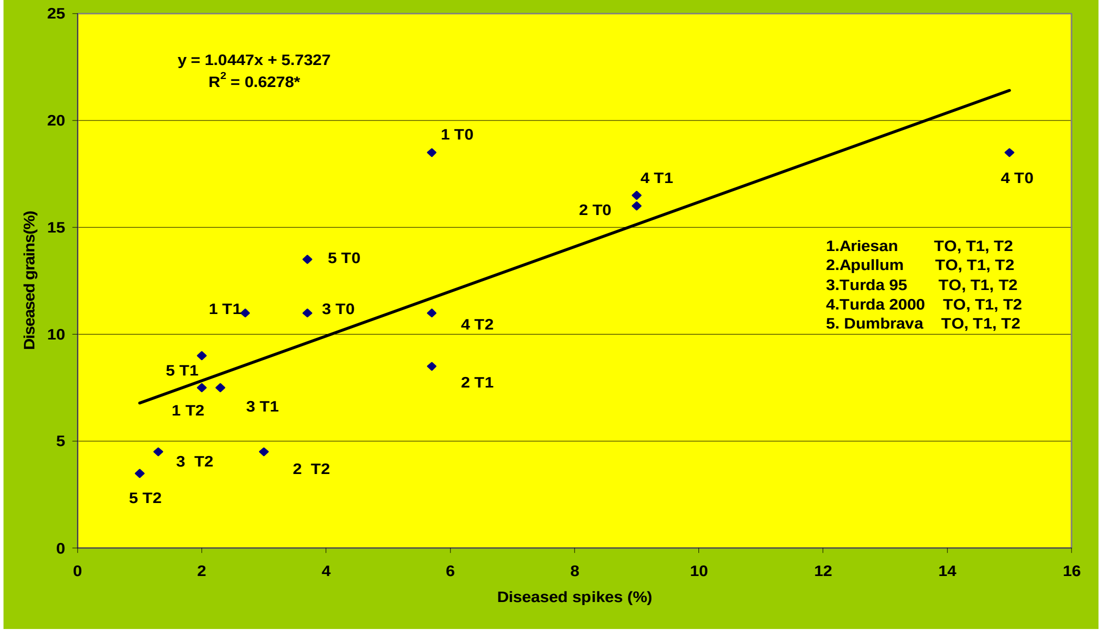
Jarroudi, M.El, Tychon, B., Maraite, H., Hoffmann, L. 2004.Epidemiological importance on the tan spot on winter wheat crop in the Grand Duch of Luxenburg. VIII ESA Congress, Copenhagen (Denmark), 11-14, july, 2004, Book of Proccedings, p. 87-88.

Jergensen, L.N., Secher Bo., J. M., Nielsen, G. C. 1996. Monitoring diseases of winter wheat on both a field and a national level in Denmark.Crop Protection vol.15, Issue 4,june: 383-390.

Osborne, L.E., Stein, J,M. 2007. Epidemiology of Fusarium head blight on small-grain cereals. International Journal of Food Microbiology vol. 119, Issue 1-2, 20 Octomber:103-108.

Fig.1.Yied (kg/ha) at five wheat cultivars, in relathionships with fungicide treatments number (Turda, 2006-2007)

Fig.2.The relation between spikes diseased (%) and grain diseases(%) l at five wheat cultivars testated in three experimental conditions



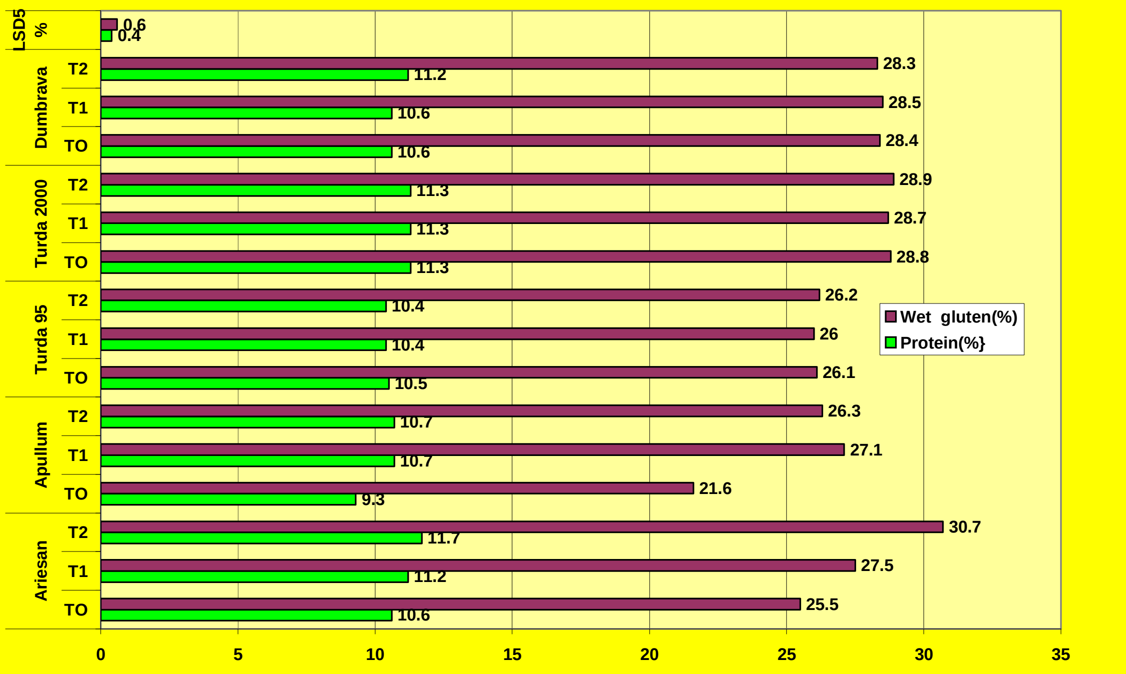


Fig.3.The influence of fungicide tratements number on the protein and wet gluten content at five wheat cultivars (ARSD, 2006-2007)

PREDICTION MODELS FOR DEOXYNIVANENOL ACCUMULATION RISK USING EMPIRICAL AND MECHANISTIC MODELING APPROACHES.

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ABSTRACT

The focus of Fusarium Head Blight (FHB) risk assessment tool (online: www.wheatscab.psu.edu) is to predict the risk of FHB epidemics with greater than 10 percent field severity (FHB index). This level of disease severity is strongly correlated with yield losses from FHB and generally associated with high levels of deoxynivalenol (DON) in harvested grain. However, there are cases when the disease symptom is not a good representation of DON accumulation, and recent research continues to indicate complex relationships between disease symptoms and accumulation of DON. Thus, in the effort of developing FHB forecasting models with better accuracy for disease severity and DON, we have employed mechanistic and empirical modeling approaches, and adjusted our focus to predict both risk of disease and DON accumulation. In the mechanistic modeling approach, simulation models were developed using a computer language STELLA (isee systems, NH) where critical steps in disease development were described by a series of differential equations. In the empirical modeling approach, potential predictor variables, which were based on weather conditions, were examined for their relationship with DON using non-parametric correlation coefficients and binary logistic regression. In both methods, weather information from up to 10 days before and 7 days after 50% anthesis was utilized. Several candidate models have been developed, and preliminary results indicated that accuracy of models for predicting the risk of DON accumulation greater than 2 ppm ranges from 65-75%. The accuracy of models developed using either mechanistic or empirical modeling approaches was similar. Models using weather information during anthesis or early stages of kernel development provided higher accuracy indicating that conducive weather during early stages of kernel development is critical to the prediction of DON contamination. Future research will focus on developing models that use only pre-anthesis weather.

INFLUENCE OF CULTIVAR RESISTANCE, INFECTION TIMING, AND INOCULUM DENSITY ON FHB DEVELOPMENT AND DON ACCUMULATION IN ASYMPTOMATIC WHEAT SPIKES.

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ABSTRACT

Deoxynivalenol (DON) is a mycotoxin that accumulates in wheat spikes infected by *Fusarium graminearum*. In general, DON levels are positively correlated with visual symptoms of Fusarium head blight (FHB), but DON also accumulates in infected wheat spikes that display no symptoms of FHB. These asymptomatic infections may result in DON contamination that exceeds the critical threshold of 2 ppm. This study was conducted to evaluate the effects of host, pathogen, and environmental factors on FHB development and DON accumulation in asymptomatic wheat grain. Three soft red winter wheat cultivars with different levels of resistance to FHB (Cooper, susceptible; Hopewell, moderately susceptible; and Truman, moderately resistant) were inoculated at four different growth stages with different inoculum densities. Inoculations were done at anthesis, one week post-anthesis, two weeks post-anthesis, and three weeks post-anthesis using spore densities of 0, 10,000, 20,000, and 30,000 spore/mL. The inoculum suspension consisted of a 1:1 mixture of macroconidia and ascospores from ten Ohio isolates of *F. graminearum.* The experimental design was a split-split plot, with cultivar as the whole-plot factor and inoculation timing and inoculation density as the sub and sub-sub plot factors, respectively. FHB index (IND) was rated at soft dough, and prior to physiological maturity, asymptomatic spikes were tagged in each plot and later individually harvested. Samples of both symptomatic and asymptomatic grain from each plot were analyzed for DON. IND and DON data were analyzed using Proc Mixed of SAS. The main and interaction effects of cultivar, inoculation timing, and inoculum density on IND, DON, and DON in asymptomatic grain were statistically significant. As expected, for all cultivars, at all inoculum concentrations, DON and IND were greatest when inoculations were done at anthesis. Both disease and DON increased with increasing spore concentrations so that the highest levels of DON and IND were observed for each cultivar when 30,000 spores/mL were applied at anthesis. For both samples from the entire plot (including diseased and diseased-free spikes) and samples of asymptomatic spikes, the critical threshold for DON (2 ppm) was exceeded in Cooper and Hopewell inoculated at anthesis, but not in Truman. Of the cultivars, Hopewell consistently had the highest mean IND and DON contamination. Hopewell was the only cultivar to accumulate DON in excess of 2 ppm in grain harvested from asymptomatic spike inoculated after anthesis. This occurred when inoculation was done one week after anthesis using 30,000 spores/mL. DON accumulation and disease development were influenced by cultivar, infection timing, inoculum density, and resulting interactions, and understanding the dynamics of these effects under different environmental conditions is crucial for predicting DON, particularly in connection to asymptomatic infections.

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INFLUENCE OF WITHIN-PLOT FHB VARIABILITY ON THE RELATIONSHIP BETWEEN FHB AND DON.

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ABSTRACT

Visual disease symptoms and accumulation of the mycotoxin deoxynivalenol (DON) in wheat grain are highly variable in Fusarium head blight (FHB) infected plots and fields. In part, this variability is the result of variability in anthesis and inoculum density within wheat fields. Wheat is most susceptible to infection at anthesis, but the extrusion of anthers occurs at different times for wheat planted in the same field and even for spikelets on the same wheat spike, resulting in heterogeneity of infection and consequently in heterogeneity of visual disease development and DON accumulation. This affects the accuracy with which DON is estimated, and understanding FHB and DON variability is critical for the development of sampling protocols and prediction of DON from FHB. This study was conducted to (1) evaluate the variability of FHB symptoms and DON within artificially inoculated plots, and (2) to explore the relationship between FHB and DON variances and mean FHB and DON. Six soft red winter wheat cultivars with varying levels of resistance to FHB infection (Cooper and 25R47, susceptible; Hopewell and AGI101, moderately susceptible; Truman and McCormick, moderately resistant) were planted in 10-ft x 30-ft plots and inoculated at anthesis using a backpack sprayer with a concentration of 50,000 spores/mL. There were three replicate plots of each cultivar. The inoculum suspension consisted of a 1:1 mixture of macroconidia and ascospores from ten Ohio isolates of *Fusarium graminearum.* At soft dough, 600 spikes (30 clusters with 20 spikes each) were tagged and rated for visual disease symptoms in each plot. After physiological maturity, clusters were harvested separately and tested for DON. Mean index (IND) and DON ranged from 0.91 to 31.58 % and 1.14 to 17.00 ppm, respectively, and index and DON variances among clusters within plots ranged from 1.43 to 140.40 and 0.51 to 39.05, respectively. Mean and variance data for index and DON were log-transformed and subjected to regression analyses using Minitab 15. There were significant linear relationships between log-transformed variances and log-transformed means for both IND and DON. This implies that, on a log-transformed scale, as mean IND and DON increased their respective variances also increased. The rate of increase in log-transformed IND variance with increase in the log of mean index was 1.33, with 96% of the variation in transformed index variance explained by the variation in the log of mean IND. For DON, the rate of increase in log-transformed DON variance with increase in the log of mean DON was 1.41 and 91% of the variation in transformed DON was explained by variation in the log of mean DON.

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INTEGRATED MANAGEMENT OF FHB AND DON IN SMALL GRAIN: 2008 UNIFORM TRIALS.

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OBJECTIVE

Evaluate the combined effect of fungicide and genetic resistance on FHB and DON in small grain.

INTRODUCTION

Fusarium Head Blight (FHB) and its associated toxin (deoxynivalenol, DON) continue to be a concern in every sector of the wheat and barley industries. Chemical, biological, and cultural management approaches, as well as genetic resistance, all contribute to FHB and DON reduction. However, when used individually, none of these approaches have been fully effective against this disease and toxin. The effects of fungicide application, genetic resistance, and residue management are highly variable and strongly influenced by the environment. Under favorable weather conditions, moderately resistant varieties may become infected and DON contamination may exceed critical threshold levels. In the case of fungicides, efficacy varies from one trial to another, with overall mean percent control between 40 and 60% for index and between 30 and 50% for DON (for the most effective fungicides). Fungicides are generally most effective at reducing FHB and DON when used in combination with moderate resistance; however, the magnitude of this interaction effect seems to vary from one cropping system to another. Beginning in 2007, coordinated studies were initiated to evaluate the integrated effects of multiple management strategies on FHB and DON in all classes of small grain. Results from trials conducted during the 2008 growing season are summarized herein.

MATERIALS AND METHODS

Field experiments were conducted to investigate the effects of fungicide and genetic resistance and FHB and DON accumulation under natural conditions. The standard experimental design was a split plot with 3 to 6 replicate blocks. Wheat variety and fungicide application served as the whole-plot and sub-plot factors, respectively. Trials were established both in fields previously planted with *Fusarium graminearum* host (corn and wheat) and non-host (canola and soybean) crops. Plot dimensions and cropping practices varied among trials (see individual trial reports for details). In general, between three and six locally adapted and commonly cultivated cultivars, with different levels of resistance to FHB, were planted. There were two adjacent plots of each cultivar in each block. Sub-plot treatments were established by applying Proline + Folicur (as a tank mix of 3 fl. oz of each, called Proline 3+3) or Prosaro (6.5 fl. oz/A) to one plot of each cultivar (at Feekes' growth stage 10.5.1) and leaving the other plot untreated. A non-ionic surfactant was added to the treatment at a rate of 0.125% v/v, and applications were made using CO_2-pressurized sprayers, equipped with Twinjet XR8002 nozzles or paired XR8001 nozzles, mounted at an angle (30 or 60°) forward and backward.

In each plot, percent FHB incidence (INC), diseased-head severity (SEV), index (IND; also known as field or plot severity), and *Fusarium*-damaged kernels (FDK) were quantified. Plots were harvested and yield and test weight determined. Milled grain samples from each plot were sent to one of the USWBSI-funded DON Testing Laboratories for DON analysis.

Analysis of variance (linear mixed model) was used to evaluate the effects of cultivar, fungicide and their interaction on FHB intensity and DON content.

RESULTS

A total of 23 trials were conducted in nine states (Kentucky, Louisiana, Minnesota, Missouri, Nebraska, New York, North Dakota, Ohio, and South Dakota). FHB intensity and DON varied from one location to another, with some trials having zero or nominal disease development and DON contamination. Trials with zero or nominal levels of disease (New York, Ohio, Minnesota, and Kentucky), were not included in this summary.

Louisiana. FHB intensity was very low in the trial conducted at Crowley, LA. Mean index and incidence ranged from 0.6 to 4.8 and 8.8 to 25.0%, respectively. Proline and Prosaro treated plots had significantly lower levels of disease than the untreated check. Averaged across all cultivars, mean index was 1.9% for Proline and 2.2% for Prosaro, compared to 3.4% for the Check.

Missouri. Two trials were conducted in Missouri to evaluate fungicide and variety effects on FHB and DON. In the first, plots were planted no-till into corn residue and in the second, no-till into soybean residue. *In the trial planted into corn stubble,* mean index, incidence and DON ranged from 2.0 to 29%, 10.0 to 47.5% and 3.7 to 18.7 ppm (Fig. 1), respectively. For index, the effects of fungicide and cultivar, but not the interaction, were statistically significant. Averaged across all cultivars, Proline 3+3 resulted in a significant reduction in index (26%) relative to the untreated check. The moderately resistant cultivars, Bess and Roane, with mean index of 2.6% percent, had significantly lower disease than the susceptible cultivar Elkhart, which had a mean index of 26.7%. Averaged across fungicide treatments, relative to Elkhart, Bess reduced index by 90%. Using the untreated, susceptible check as reference for comparison, the combination of fungicide and moderate resistance (Proline 3+3 applied to Bess) also reduced index by 90%. For DON, all main and interaction effects were statistically significant. The untreated, susceptible check (Elkhart without fungicide) with mean DON of 18.7 ppm had significantly higher DON contamination that the fungicide-treated resistant cultivars (Roane and Bess + Proline 3+3). The Bess + Fungicide treatment combination led to a 80% reduction in DON relative to the untreated, susceptible check.

For the trial planted into soybean stubble, mean index, incidence, and DON ranged from 0.7 to 18.9%, 5.8 to 32.5%, and 0.6 to 4.7 ppm (Fig. 1), respectively. For both index and DON, all main and interaction effects were statistically significant. Again, the Bess + Proline and Roane + Proline treatment combinations had significantly lower levels of index and DON than the untreated susceptible check (Elkhart without fungicide). The resistance x fungicide treatment combination led to a 85% reduction in DON and a 93% reduction in index relative the untreated susceptible check.

Nebraska. Mean index ranged from 14.7 to 33.4% and mean DON from 8.4 to 15.0 ppm. Only the main effect of cultivar was statistically significant for index, with mean values of 15.6, 32.4 and 24.9% for Harry, Jagalene and Pioneer 21R37, respectively. The difference in index between Harry and Jagalene, 16.8%, represented a 52% reduction in index due to difference in susceptibility. For DON, the main effects of fungicide and cultivar were statistically significant. Pioneer 21R37, with an average DON of 9.2 ppm, had significantly lower DON contamination than Harry and Jagalene, both with a mean DON contamination of 13.6 ppm.

North Dakota. *Two-row Barley.* For the trial planted into canola residue, mean index and DON were low, ranging from 1.4 to 5.2% for index and 0.1 to 1.3 ppm for DON (Fig. 1). However, incidence exceeded 60% in some treatment combinations. Based on index, the effects of cultivar and fungicide, but not the interaction, were statistically significant. Conlon and Rawson and Eslick and Merit had the lowest and highest levels of disease, respectively. A similar trend was observed in the trial planted into the residue of HRSW.

The overall level of disease was also low in the latter trial, with mean index between 1.3 and 5.5% and incidence between 43 and 74%. Mean DON did not exceed 2 ppm.

Six-row Barley. For the trial planted into canola residue, mean index ranged from 6 to 13.3% and mean incidence from 88 to 100%. Only the main effect of cultivar was statistically significant. Averaged across fungicide treatments, Legacy with a mean index of 6.2% and ND20448 with a mean index of 13.2% had the lowest and highest levels of disease, respectively. Similarly, only cultivar had a significant effect on index in the trial planted into residue of HRSW. ND20448 and Tradition with mean index of 15 and 12%, respectively, had the highest levels of disease, whereas Legacy had the lowest, with mean index of 6.5%.

Durum. For both trials (wheat planted after canola and wheat planted after wheat), the effects of fungicide, cultivar, and their interaction on FHB intensity were not statistically significant. This was probably due to the fact that the variability among replicates of the same treatment was very high in both trials.

CONCLUSIONS

Percent control was estimated for a few of the trials to evaluate the efficacy of individual treatments and treatment combinations against index and DON. Trials with nominal levels of disease and DON were not included in this calculation because percent control tends to be highly variable at low index and DON levels. In general, moderately resistant variety x fungicide treatment combination resulted in the highest percent control. Comparing trials with the same treatment combinations, but planted into different types of crop residue, none-host crop + moderately resistant variety + fungicide generally resulted in higher percent control than host crop + susceptible variety + without fungicide.

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DISCLAIMER

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.

REFERENCES

Champeil, A., and Fourbet, J. F. 2004. Fusarium head blight: epidemiological origin of the effects of cultural practices on head blight attacks and the production of mycotoxins by *Fusarium* in wheat grains. Plant Sci. 166:1389-1415.

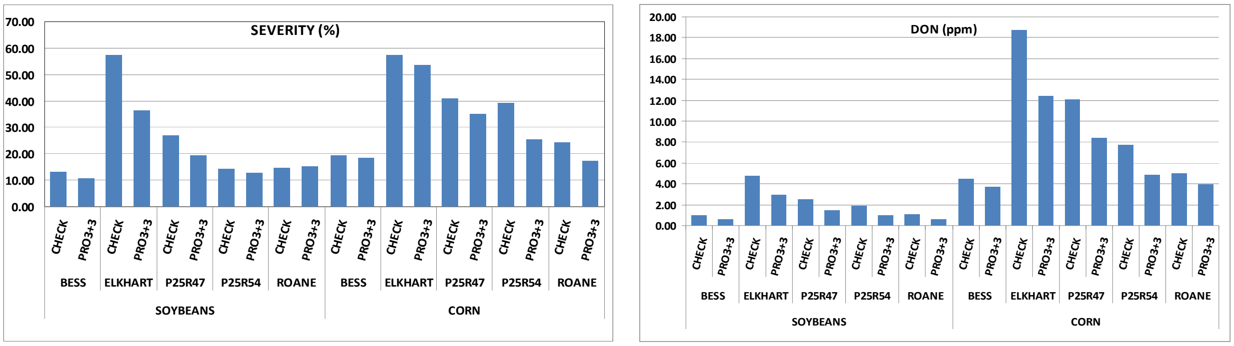
Paul, P. A., Lipps, P. E., Hershman, D. E., McMullen, M. P., Draper, M. A., and Madden, L. V. 2008. Efficacy of triazole-based fungicides for Fusarium head blight and deoxynivalenol control in wheat: A multivariate meta-analysis. Phytopathology 98:999-1011.

Dill Macky, R., and Jones, R. K. 2000. The effect of previous crop residues and tillage on Fusarium head blight of wheat. Plant Dis. 84:71-76.

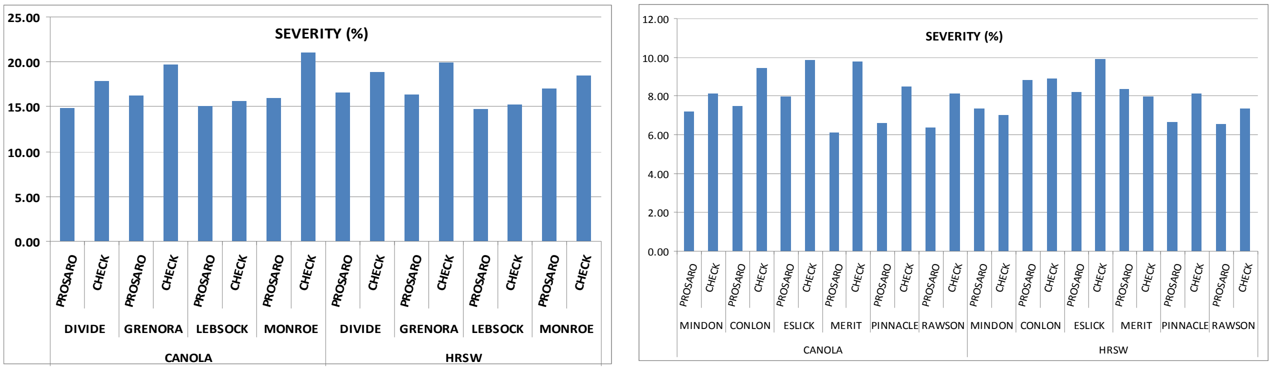
McMullen, M., Milus, G., and Prom, L. 1999. 1999 Uniform fungicide trials to identify products effective against Fusarium head blight in wheat. Pages 64-68 in: Proc. Of the 1999 National Fusarium Head Blight Forum, Sioux Falls, SD, Dec. 5-7, 1999. Michigan State Univ.

Nita, M., DeWolf, E., Madden, L., Paul, P., Shaner, G., Adhikari, T., Ali, S., Stein, and Osborne, L. 2006. Effect of corn residue level, fungicide application, and cultivar resistance level on disease incidence and severity of Fusarium head blight and DON concentration. Page 46 in: Proc. 2006 National *Fusarium* Head Blight Forum, Dec. 10-12, 2006, Research Triangle Park, NC. East Lansing: Michigan State University.

Schaafsma, A. W. Tamburic-Ilincic, and Hooker, D.C. 2005. Effect of previous crop, tillage, field size, adjacent crop, and sampling direction on airborne propagules of *Gibberella zeae/ Fusarium graminearum*, fusarium head blight severity, and deoxynivalenol accumulation in winter wheat. Can. J. Plant Pathol. 27:217-224.



Missouri SRWW
Missouri SRWW



North Dakota – Durum wheat
North Dakota – Two-row barley

Fig.1. Graphs showing side-by-side comparisons of FHB and DON response to fungicide, cultivar and fungicide x cultivar combinations.

INTEGRATING FUNGICIDE AND VARIETY RESISTANCE TO MANAGE FHB/DON IN WHEAT IN DIFFERENT CROPPING SYSTEMS.

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ABSTRACT

Fusarium head blight (FHB) and its associated toxins (especially deoxynivalenol, DON) continue to be a concern in all major wheat-growing regions of the world, causing substantial yield and quality losses. Through years of research funded by the US Wheat and Barley Scab Initiative (USWBSI), several chemical, biological, and cultural management approaches, as well as genetic resistance, have been tested and shown to contribute to FHB and DON reduction. However, when used individually, none of these approaches have been fully effective against FHB and DON. The effects of fungicide, genetic resistance, and residue management through crop rotation and tillage are highly variable and strongly influenced by environment conditions. Beginning in 2007, coordinated studies were initiated to evaluate the integrated effects of multiple management strategies on FHB and DON in all classes of small grain. In particular, studies are being conducted to determine: 1) whether combining fungicide and genetic resistance results in a greater percent reduction of FHB and DON than fungicide or resistance alone and 2) whether the relative magnitude of the reduction varies with wheat class, weather condition, and cropping system. Preliminary results indicate that in general, when FHB and DON levels are moderate to high, combining fungicide and genetic resistance leads to an overall reduction in FHB and DON that is greater than that achieved by either approach used alone. For the studies evaluated thus far, combining the most resistant cultivar with the most effective fungicide results in the lowest levels of FHB and DON in all wheat classes and cropping systems, with percent reduction relative to the untreated, susceptible check as high as 90% for FHB index and 65% for DON, in some cases. However, for a given cultivar and fungicide, the magnitude of the reduction varies from one cropping system to another. Further analyses will be conducted to determine the significance and consistency of the difference in fungicide x resistance interaction effects among cropping systems in all wheat classes.

ACKNOWLEDGEMENT AND DISCLAIMER

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2008 UNIFORM FUNGICIDE PERFORMANCE TRIALS FOR THE SUPPRESSION OF FUSARIUM HEAD BLIGHT IN SOUTH DAKOTA.

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ABSTRACT

Fusarium head blight (FHB – scab) remains a serious concern for wheat and barley producers in South Dakota. The objective of this study was to continue to evaluate the efficacy of various fungicides and fungicide combinations for the suppression of Fusarium head blight and other wheat diseases. One hard red winter wheat cultivar 'Wesley' was planted at two South Dakota locations (Brookings and South Shore/Watertown). Two hard red spring wheat cultivars, 'Briggs' and 'Oxen', were planted at three South Dakota locations (Brookings, Groton, and South Shore/Watertown) and Robust barley was planted at Brookings. Studies at two of these sites were conducted under ambient conditions. At the Brookings site, both the barley and the spring wheat trials received supplemental mist irrigation. Trial treatments from the Uniform Fungicide Trial treatments list for the suppression of FHB included an untreated check, Folicur (tebuconazole) applied at 4.0 fl oz/A, Proline (prothioconazole) applied at 5 fl oz/A, Prosaro (a premix of prothioconazole and tebuconazole) applied at 6.5 fl oz/A, Caramba (metconazole) applied at 10 fl oz/A, Caramba (metconazole) applied at 14 fl oz/A and Topguard (flutriafol) applied at 14 fl oz/A. All treatments included Induce, a non-ionic surfactant, applied at 0.125% v/v. Spring wheat trials were planted in a factorial randomized complete block design with six replications. The winter wheat and the barley trial included four replications. Trial treatments were applied at anthesis (Feekes growth stage 10.51). The spring wheat and barley plots at the Brookings location were inoculated by spreading *Fusarium graminearum* (isolate Fg4) inoculated corn (*Zea mays*) grain throughout the field and providing overhead mist irrigation applied from 8:00 pm until 8:00 am each day for ten days two weeks following anthesis. Other sites had natural inoculum from corn stalk residue and natural moisture conditions. Twenty-one days following treatment, plots were evaluated for leaf diseases, FHB incidence, FHB head severity, and FHB field severity. Samples were collected for Fusarium damaged kernels (FDK), deoxynivalenol (DON), grain yield, and test weight. FHB data in the winter wheat trials were non-significant except for FDK (both locations). Yield differences in the winter wheat trial at Brookings may be related to the highly significant differences in leaf rust control. Spring wheat at all locations had non-significant FHB incidence, however, one location (Groton) showed significant differences in FHB Severity and Disease Index. Yield was also significant in two locations in the spring wheat trial but differences in leaf rust control may have contributed to yield differences as leaf rust developed late in the plots. Significant differences for FHB Incidence and Disease Index occurred in the barley trial; however, FHB Severity and yield were non-significant. Total leaf disease pressure was very significant, as was late season leaf rust pressure.

ACKNOWLEDGEMENT AND DISCLAIMER

This material is based upon work supported by the U.S. Department of Agriculture, under Agreement No. 59-0790-4-097. 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 authors and do not necessarily reflect the view of the U.S. Department of Agriculture.

2008 UNIFORM TRIALS FOR THE PERFORMANCE OF BIOLOGICAL CONTROL AGENTS IN THE SUPPRESSION OF FUSARIUM HEAD BLIGHT IN SOUTH DAKOTA.

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ABSTRACT

Fusarium head blight (FHB – scab) remains a serious concern for wheat and barley producers in South Dakota. The objective of this study was to continue to evaluate the efficacy of various fungicides and fungicide combinations for the suppression of Fusarium head blight and other wheat diseases under SD conditions. Briggs hard red spring wheat and Robust barley were planted at Brookings, South Dakota. Trial treatments included an untreated check; Prosaro (a premix of prothioconazole and tebuconazole) applied at 6.5 fl oz/A; TrigoCor 1448 (*Bacillus* sp.) from Cornell University, Ithaca, NY; and TrigoCor 1448 + Prosaro coapplied; Taegro (*Bacillus* sp.) from Novozymes; and Taegro + Prosaro coapplied; 1BA (*Bacillus subtilus*) from South Dakota State University, Brookings, SD; 1BA + Prosaro coapplied. The treatments were applied at anthesis. Plots were inoculated by spreading *Fusarium graminearum* (isolate Fg4) inoculated corn (*Zea mays*) grain throughout the field and providing overhead mist irrigation applied from 8:00 pm until 8:00 am each day for ten days following anthesis. Twenty-one days following treatment, plots were evaluated for FHB incidence, FHB head severity, and FHB field severity. Plots were harvested for yield and test weight and samples were collected for Fusarium damaged kernels (FDK) and deoxynivalenol (DON).

Similar to 2007, the dry weather at flowering in 2008 affected widespread disease development even with an amended environment. In the data analysis, the assessments of FHB Incidence are significant in the barley and spring wheat studies. However, FHB Severity, FHB Disease Index and the yield differences were non-significant.

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COMPARING THE EFFECTS OF MACROCONIDIA AND ASCOSPORES OF *GIBBERELLA ZEAE* ON FUSARIUM HEAD BLIGHT DEVELOPMENT IN WHEAT.

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ABSTRACT

Gibberella zeae (Schwein.) Petch (anamorph: *Fusarium graminearum*) is the primary causal agent of Fusarium Head Blight (FHB) of Wheat in North America. FHB is incited by both sexually produced ascospores and asexually produced macroconidia, with ascospores often considered the epidemiologically important inoculum for FHB development. However, in the field, both ascospores and macroconidia may be equally abundant at the time of crop anthesis and likely contribute equally to FHB development. The objective of this study was to compare the effects of inoculum type and density on FHB development under controlled conditions. During the summer of 2008, SRWW cultivar Cooper (susceptible) was grown under greenhouse conditions at the Ohio Agricultural Research and Development Center (OARDC) in Wooster, OH. Macroconidia and ascospores were harvested from mung bean agar and carrot agar, respectively, and used to inoculate plants at anthesis. Four different inoculum densities (5, 10, 15 and 20 x10^5 spores per mL) were prepared for each spore type, and separate groups of approximately 20 plants were spray-inoculated with each spore type x density combination. The experimental design was a split-plot with spore type as whole plot and inoculum density as sub-plot. The experiment was repeated five times, with each time considered a block. After inoculation, plants were incubated in a mist chamber for 24 h and then moved to a greenhouse where FHB development was monitored. Disease incidence was assessed at 24-hour intervals for 21 days after inoculation (DAI) as the proportion of plants with symptoms of FHB. Macroconidia consistently resulted in numerically higher FHB incidence than ascospores at all inoculum densities, at every assessment time. For both spore types, between 5 and 7 DAI, there was a linear increase in incidence with inoculum density, with similar regression slopes for both spore types. However, the intercept (high of the regression line) was greater for macroconidia than ascospore. Depending on the inoculum density, maximum incidence ranged from 93 to 100% for macroconidia and from 80 to 95% for ascospores. Maximum incidence was reached earlier on macroconidia- than ascospore-inoculated plants. At 14 and 21 DAI, incidence was significantly higher on plants inoculated with macroconidia than on those inoculated with ascospore at the two lower inoculum densities, but not at the higher densities. Under the conditions of this study, based on FHB incidence, macroconidia appear to be more efficient at inciting FHB than ascospores. Our results showed that fewer macroconidia than ascospores were required to achieve a similar level of incidence; for a given inoculum density, macroconidia resulted in higher mean incidence than ascospores; and at lower inoculum densities, a given level of incidence was reached earlier for inoculations done with macroconidia than with ascospores.

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EVALUATION OF PROTOTYPE COMMERCIAL MEDIA FOR THE PRODUCTION OF FUSARIUM HEAD BLIGHT ANTAGONIST *CRYPTOCOCCUS FLAVESCENS* OH 182.9.

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OBJECTIVES

1.) Develop a prototype commercial medium for liquid culture production of *Cryptococcus flavescens* OH 182.9 that utilizes inexpensive industrial grade sources of carbon and nitrogen and 2.) Test cells of *C. flavescens* OH 182.9 produced in the selected commercially feasible medium for equivalence in quantity and Fusarium head blight (FHB) biocontrol efficacy to cells produced in the laboratory grade medium SDCL.

INTRODUCTION

While research has shown disease forecasting, resistant varieties, cultural controls, fungicides, and biocontrol agents to be incrementally useful, as individual strategies, in reducing FHB (Dill-Macky and Jones, 2000; Schisler et al., 2002; Beyer et al., 2006; Paul et al., 2007), the integration of multiple control measures offers the best opportunity to substantially and consistently reduce FHB. Using biological control as part of the integrated management of FHB is understudied yet has considerable potential for significantly contributing to the reduction of FHB and DON (Milus et al., 2001). However, the development of a cost effective, commercially feasible medium for producing *C. flavescens* OH 182.9 is a prerequisite step for the inclusion of this agent in the integrated management of FHB.

To date, biomass production of OH 182.9 has been carried out in a laboratory grade medium (SDCL, Slininger et al. 2007) containing a highly purified protein digest product. Using this medium, we have completed crucial studies on optimizing medium carbon loading and C:N ratio to enhance the production and biocontrol efficacy of OH 182.9 biomass. However, the medium is impractical for commercial use due to the high cost of the protein digest component.

MATERIALS AND METHODS

Media with carbon and nitrogen supplied in large part by one of two different cotton seed-derived industrial protein products (Proflo and Pharmamedia, Traders Protein, Memphis, TN) or an industrial source of casein digest (Hy-Case Amino, Kerry Bio-Science, Norwich, NY) were developed using carbon loading and C:N ratios that approximated those of SDCL. Cell production studies were conducted both in shake flasks and benchtop fermentors. For shake flask studies, log-growth phase cells of strain OH 182.9 were transferred to 250 ml Erlenmeyer flasks containing 50 mls of Proflo, Pharmamedia, Hy-Case or SDCL media. Flasks were inoculated to 0.1 OD (A_{620}), incubated at 25°C and 250 rpm with a 2.5 cm stroke for 48 hours, and harvested for determination of CFU/ml and/or use of OH 182.9 biomass in greenhouse studies. In separate replicated studies, cells of OH 182.9 were produced in bench-top fermentors (B Braun Biostat B fermentors, B. Braun Biotech Inc., Allentown, PA) that were charged with 1.5 L of one of the four media types. Antifoam 204 (Sigma, St Louis, MO) was added prior to medium sterilization and cultures were not pH controlled after inoculation at pH 7.0. Log-growth cells of OH 182.9 served as a 5% seed inoculum. Fermentors were operated at 25°C, 1.5L/min aeration and 200 rpm agitation. After dissolved oxygen had recovered to saturation at 48 hours, cells were harvested for determination of CFU/ml and/or use in greenhouse or field trials. Data was analyzed using one-way ANOVA and Fisher's Protected LSD (Pd"0.05).

Hard red spring wheat (cultivar Norm) was grown in plant growth chambers prior to conducting plant bioassays on greenhouse benches. Conidial inoculum of *Fusarium graminearum* isolate Z-3639 was produced on clarified V8 juice agar under 12 h/day fluorescent light for 7 days at 24°C. At wheat anthesis, one-quarter-strength suspensions of OH 182.9 biomass from the four media were individually misted onto approximately 14 wheat heads per treatment followed immediately by a mist application of a conidial suspension (2 x 10^4 conidia/ml). Heads treated with water followed by the conidial suspension of *F. graminearum* isolate Z-3639 served as the control. Plants were placed in humidity tents for 3 days, scored for disease severity after 16 days, and data analyzed using one-way ANOVA and Fisher's Protected LSD ($P \leq 0.05$). The reported means are results from pooled replicate experiments.

Field trials were conducted in Peoria, IL and in Wooster, OH in 2008. Biomass of OH 182.9 from the four media was applied to soft red winter wheat cultivar Pioneer Brand 2545 at the beginning of wheat flowering at approximately 85% strength and 20 gal/acre. Corn kernels colonized by *F. graminearum* were scattered through plots (~25-40 kernels/m^2) two to three weeks prior to wheat flowering and mist irrigation was provided periodically for approximately two weeks after treatment application. Heads were scored for disease incidence and severity 20-25 days after treatment using a 0-100% scale. Randomized complete block designs were used in all field trials. Analysis of variance and the Bonferroni mean comparison test ($P \leq 0.05$) were used to compare treatment means.

RESULTS AND DISCUSSION

In shake flask studies, higher cell counts were obtained in SDCL and Hy-Case media than in the Proflo and Pharma media (Table 1). In general, higher cell counts were obtained in the bench top fermentors with the SDCL medium supporting higher counts than the other three media (Table 1). Though OH 182.9 cells tended to reduce FHB severity and incidence when produced in both shake flasks and fermentors, cell production media did not have a significant effect on efficacy in greenhouse trials (Table 2).

Because the Hy-Case medium tended to support OH 182.9 cell production that was nearly equivalent to SDCL (Table 1), these two media were utilized to produce biomass for field trials. Treatment means for DS and DON did not differ significantly from the control in either field location (Table 3). Treatment effects with cells of OH 182.9 produced in the Hy-Case medium were variable with DON being reduced by 41% (NSD) compared to controls in Peoria, IL but having no effect on DON in Wooster, OH (Table 3).

Compared to the SDCL medium, the Hy-Case prototype commercial medium supported the production of nearly equivalent numbers of OH 182.9 cells that were also comparable in biocontrol efficacy to those produced in the SDCL medium. Though the Hy-Case medium was shown to be the most commercially feasible medium of those tested, current work on isolating variants of OH 182.9 with enhanced efficacy may require adjustments of the Hy-Case medium to meet the altered nutritional requirements of improved OH 182.9 strains.

ACKNOWLEDGEMENT

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DISCLAIMER

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. Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.

REFERENCES

Beyer, M., Klix, M.B., Klink, H. and Verreet, J.A., 2006, Quantifying the effects of previous crop, tillage, cultivar and triazole fungicides on the deoxynivalenol content of wheat grain - A review. Journal of Plant Diseases and Protection, 113(6): 241-246.

Dill-Macky, R., and Jones, R.K., 2000, The effect of previous crop residues and tillage on Fusarium head blight of wheat, *Plant Dis*. 84:71-76.

Milus, E.A., Hershman, D., and McMullen, M., 2001, Analysis of the 2001 uniform wheat fungicide and biocontrol trials across locations, Proceedings of the 2001 National Fusarium Head Blight Forum, Kinko's, Okemos, MI. pgs 75-79.

Paul, P.A., Lipps, P.E., Hershman, D.E., McMullen, M.P., Draper, M.A., and Madden, L.V., 2007b, A quantitative review of tebuconazole effect on Fusarium head blight and deoxynivalenol content in wheat. Phytopathology 97:211-220.

Schisler, D.A., Khan, N.I., Boehm, M.J., and Slininger, P.J., 2002, Greenhouse and field evaluation of biological control of Fusarium head blight on durum wheat. Plant Disease 86:1350-1356.

Slininger, P.J., Schisler, D.A., Ericsson, L.D., Brandt, T.L., Frazier, M.J., Woodell, L.K., Olsen, N.L., and Kleinkopf, G.E., 2007, Biological control of post-harvest late blight of potatoes. Biocontrol Science and Technology 17: 647-663.

Table 1. Shake flask and bench-top fermentor production of cells of Fusarium head blight antagonist *Cryptococcus flavescens* OH 182.9 in various prototypes of commercial production media[a,b]

	CFU/ml at 48 h Harvest[c]	
Medium	Shake Flask[d]	Bench-top Fermentor[e]
SDCL	2.80×10^8 A	5.36×10^8 A
Hy-Case	2.38×10^8 A	3.75×10^8 B
Proflo	1.79×10^8 B	3.54×10^8 B
Pharma	1.55×10^8 B	3.14×10^8 B
P value	0.004	0.001

[a] Within a column, values not followed by the same letter are significantly different (Fisher's Protected LSD, $P \leq 0.05$). Average results from two experiments are presented.
[b] See "Materials and Methods" for descriptions of antagonist production media.
[c] CFU/ml= Colony forming units per milliliter.
[d] 250 ml flasks charged with 50 ml growth medium per flask, 48 h cell harvest
[e] Bench-top fermentor vessel capacity of 2 liters charged with 1 liter of medium, 48 h cell harvest.

Table 2. Greenhouse assay of the influence of *Cryptococcus flavescens* OH 182.9 on Fusarium head blight when antagonist cells were produced in differing prototypes of commercially feasible production media[a,b,c]

Treatment	Cell Production Vessel			
	Shake Flask		Bench-top Fermentor	
	DS (%)	INC (%)	DS (%)	INC (%)
OH 182.9 in SDCL	35 A	61 A	60 A	72 A
OH 182.9 Hy-Case	37 A	64 A	68 A	85 A
OH 182.9 Proflo	39 A	62 A	80 A	88 A
OH 182.9 Pharma	56 A	76 A	60 A	69 A
F. graminearum Control	51 A	69 A	75 A	88 A
P value	0.19	0.69	0.09	0.06

[a] Within a column, values not followed by the same letter are significantly different (Fisher's Protected LSD, P≤0.05). Average results from 2 experiments are presented.
[b] See "Materials and Methods" for descriptions of antagonist production media.
[c] DS=Disease severity, INC=Disease incidence

Table 3. Influence of *Cryptococcus flavescens* OH 182.9 on Fusarium head blight and DON in Peoria, IL and Wooster, OH field trials on Pioneer Brand 2545 wheat when antagonist cells were produced in differing prototypes of commercially feasible production media[a,b,c]

Treatment	Field Trial Location			
	Peoria, IL		Wooster, OH	
	DS (%)	DON (ppm)	DS (%)	DON (ppm)
Control	8.0 A	11.8 A	11.9 A	8.1 A
OH 182.9 SDCL	7.6 A	13.6 A	12.6 A	6.8 A
OH 182.9 Hy-Case	5.5 A	6.9 A	11.6 A	8.1 A

[a] Within a column, values not followed by the same letter are significantly different (Bonferroni mean comparison test, P≤0.05). Average results from 2 replicate experiments are presented.
[b] See "Materials and Methods" for descriptions of antagonist production media.
[c] DS=Disease severity, INC=Disease incidence

FUNGICIDES CONTROL OF FUSARIUM HEAD BLIGHT SYMPTOMS CAUSED BY 15-ADON AND 3-ADON *FUSARIUM GRAMINEARUM* ISOLATES IN INOCULATED AND MISTED WHEAT PLOTS IN ONTARIO, CANADA.

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INTRODUCTION

Fusarium graminearum (Schwabe) causes Fusarium head blight (FHB), an important wheat disease. Deoxynivalenol (DON) is the most important mycotoxin produced by *F. graminearum*; 15-acetyl DON (15-ADON) and 3-acetyl DON (3-ADON) analogs may also be produced. A shift in the presence of two *F. graminearum* chemotypes, 15-ADON and 3-ADON was identified in North America (Ward et al. 2008). In Ontario, Canada, *F. graminearum* isolates collected from 2004 to 2007 from winter wheat were mainly of the 15-ADON chemotype (Tamburic-Ilincic et al. 2006, Tamburic-Ilincic et al. 2008). The shift of chemotypes may influence current FHB management strategies including the use of fungicides. FOLICUR (tebuconazole) and PROLINE (prothioconazole) are two fungicides commonly used for FHB control in Ontario, Canada, while PROSARO may be newly registered for commercial application and has active ingredients from both FOLICUR and PROLINE. The objective of this study was to investigate the effect of FOLICUR, PROLINE and PROSARO on FHB symptoms in two spring wheat cultivars after inoculation with 15-ADON and 3-ADON *Fusarium graminearum* isolates in inoculated and misted wheat plots.

MATERIALS AND METHODS

Roblin (FHB highly susceptible-HS) and Alsen (FHB moderately resistant-MR) spring wheat were planted in mid April 2008 in Ridgetown, Ontario. The experiment was designed as a split plot arranged in a randomized complete block design, with blocks replicated three times. Six isolates of *F. graminearum* (three 15-ADON and three 3-ADON) were used as treatments. The plots were fertilized and maintained using provincial recommendations. The fungicide treatments consisted of FOLICUR, PROLINE, PROSARO, and water that were applied at approximately 50% anthesis for each cultivar (Zadoks 65). Two days after the fungicides were applied, plots were spray-inoculated with a suspension of macroconidia of a single *Fusarium graminearum* isolate at 50,000 spores mL^{-1}. The suspension was produced in liquid shake culture using modified Bilay's medium. Plots were misted with approximately 7.5 mm of water daily for 2 weeks after inoculation. Each variety was assessed for visual symptoms at the early dough stage (Zadoks 83) by randomly selecting 20 heads for disease incidence and severity. Disease levels were calculated as Fusarium head blight index (FHBI), which was the product of the percent heads infected and the percent spikelets infected, divided by 100.

RESULTS AND DISCUSSIONS

A significant interaction between fungicides and cultivars was reported for FHB index (Table 1). FHBI (%) was lower in Alsen cultivar (FHB-MR) than in Roblin (FHB-HS) after application of any fungicides or in control (Figure 1). The lowest FHB index in Alsen was recorded after PROSARO application (Figure 1). In the present study, there was no interaction between fungicides and isolates, or between cultivars and isolates, on FHBI (Table 1). A high variation in FHB index was detected among isolates of both 15-ADON chemotype and 3-ADON chemotype (Figure 2), suggesting that isolates ability to produce FHB symptoms might be more important than chemotypes. In the present study, the fungicides reduced FHB index after inoculation with *F. graminearum* 15-ADON or 3-ADON isolates compared to control, except FOLICUR application after inoculation with 3-ADON isolate 2 (Figure 3). More *F. graminearum* 3-ADON isolates need to be tested to verify this.

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REFERENCES

Tamburic-Ilincic, L., A.W. Schaafsma, R. M. Clear, T. J. Ward, and K. L. O'Donnel. 2006. Chemotype of *Fusarium graminearum* isolates from winter wheat collected in Ontario in 2004. Can. J. Plant Pathol. Vol. 28 (2). 340. Abstract.

Ward, T.J., Clear, R.M., Rooney, A.P., O Donnell, K., Gaba, D., Patrick, S., Starkey, D.E., Gilbert, J., Geiser, D.M., Nowicki, T.W. 2008. An adaptive evolutionary shift in Fusarium head blight pathogen populations is driving the rapid spread of more toxigenic Fusarium graminerarum in North America. Fungal Genetics and Biology. 45:473-484.

Tamburic-Ilincic, L., D. Gaba, T. Nowicki, A.W. Schaafsma, and D. Fernando. 2008. Chemotypes of *Fusarium graminearum* isolates and accumulation of deoxynivalenol (DON), 15-ADON AND 3-ADON in naturally infected and inoculated winter wheat in Ontario, Canada. Cereal Research Communications. Vol. 36 (B) 623-624.

Zadoks, J. C., Chang, T. T., and Konznak, C. F. 1974: A decimal code for the growth stages of cereals. Weed Research. 14:415-421.

Table 1. Analysis of variance for the effect of Fungicides, Cultivars, Isolates and their interactions on Fusarium head blight index (FHB %).

SOURCE	DF	MEAN SQUARE	F	Prob (F)
Fungicides	3	420.019	7.89	0.0001
Cultivars	1	9635.057	181.13	0.0001
Fungicides x Cultivars	3	205.880	3.87	0.0117
Isolates	5	534.512	10.04	0.0001
Fungicides x Isolates	15	24.162	0.45	0.957
Cultivars x Isolates	5	97.450	1.83	0.114
Fungicides x Cultivars x Isolates	15	33.651	0.63	0.841
Error	94	53.192		

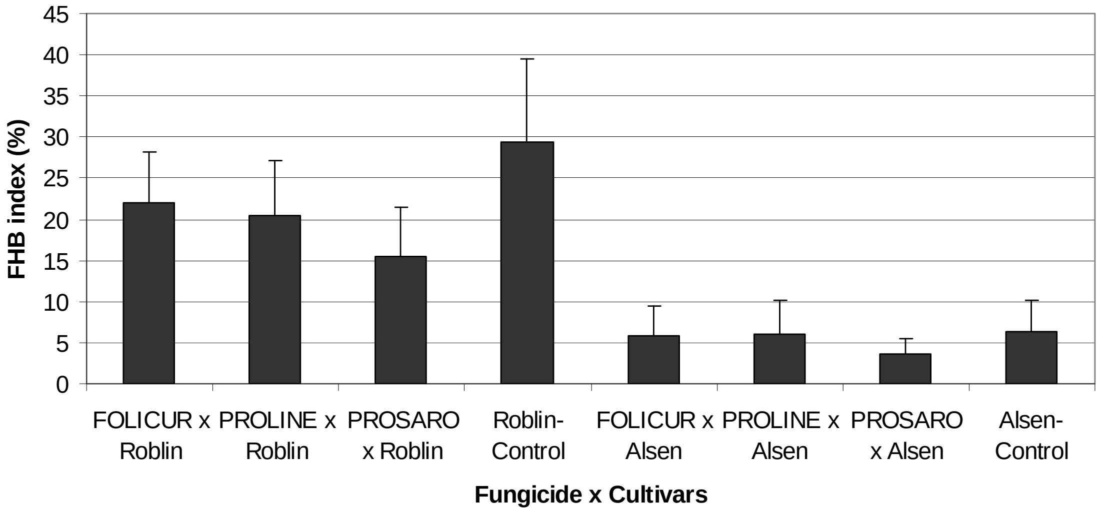


Figure 1. The effect of fungicides x cultivars interaction (+ standard deviation) on Fusarium head blight index (FHB %).

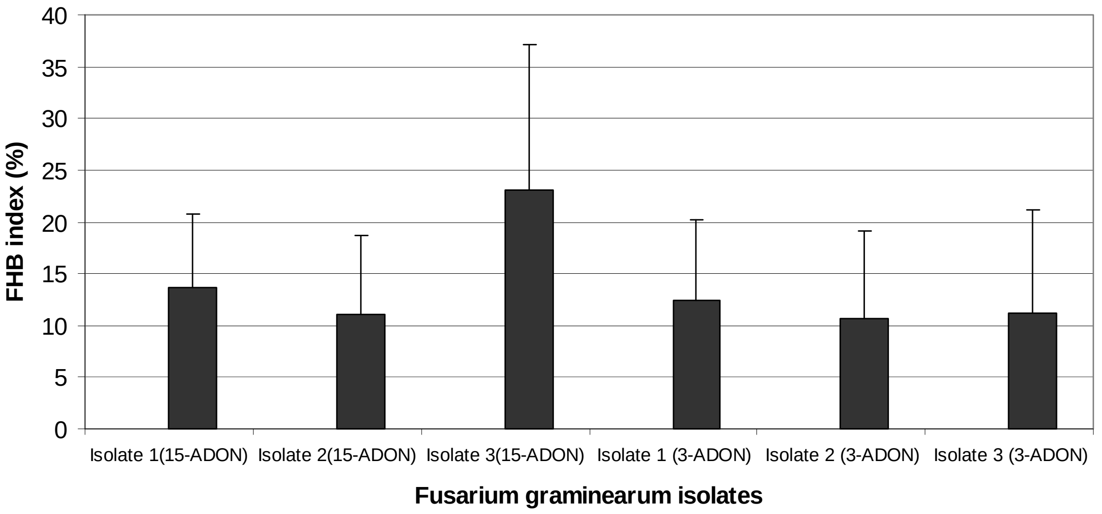
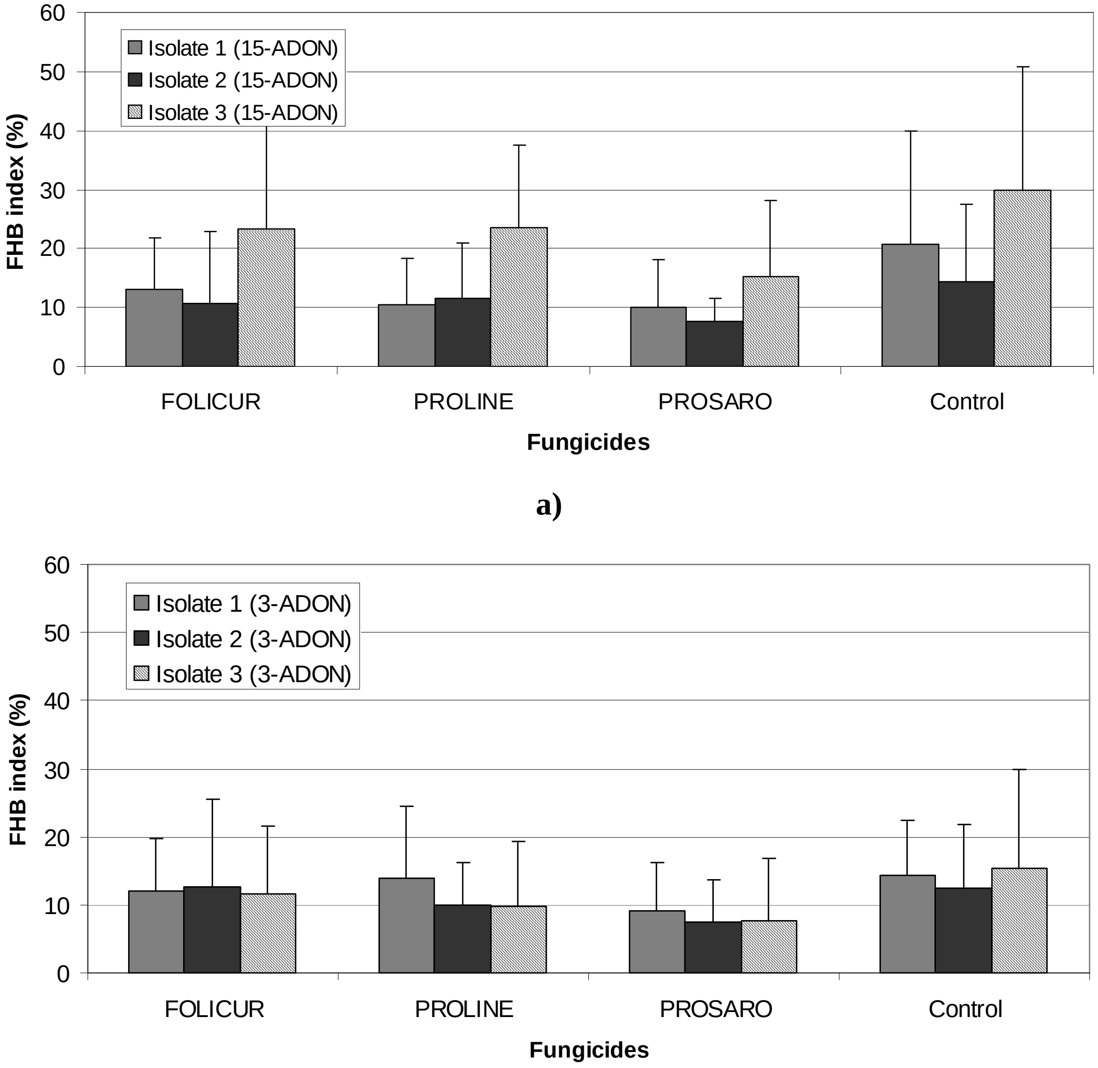


Figure 2. The effect of *Fusarium graminearum* 15-ADON isolates and 3-ADON isolates (+ standard deviation) on Fusarium head blight index (FHB %).



a)

b)

Figure 3. The effect of fungicides on Fusarium head blight (FHB) index (%) in wheat after inoculation with a) *F. graminearum* 15-ADON isolates and b) *F. graminearum* 3-ADON isolates (+ standard deviation).

EVALUATION OF INTEGRATED FHB MANAGEMENT METHODS UNDER LOW DISEASE ENVIRONMENTS IN NEW YORK.

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OBJECTIVE

To evaluate the individual and interactive effects of resistant cultivars, foliar fungicide (Prosaro), and a biological control agent (*Bacillus subtilis*) on wheat yield and the integrated management of Fusarium head blight (FHB) and deoxynivalenol DON under four natural environments in New York.

INTRODUCTION

In response to the USWBSI goal to validate integrated management strategies for FHB and DON, the Disease Management RAC of USWBSI initiated a multi-state, multi-year, coordinated field study. In New York during 2007 and 2008, we conducted a total of four separate experiments each with unique environmental conditions during flowering and early grain development.

MATERIALS AND METHODS

All experiments were performed at the Musgrave Research Farm in Aurora, NY following cultural practices recommended for winter wheat in the region. The four experimental wheat environments were characterized by the planting of winter wheat 1) following soybean harvest and moldboard plowing in late September 2006; 2) no-till into corn residue in early November 2006; 3) no-till into soybean residue in late September 2007; and 4) no-till into corn residue in early October 2007. Each experimental design was a split plot with four wheat cultivars as whole plots and four spray treatments as subplots, and four replicate blocks. Main plots were planted with 10 ft wide commercial grain drills. Sprayed areas in each subplot were 8 ft wide by 20 ft long. Spray treatments applied at Feekes GS10.5.1 were 1) non-sprayed; 2) Prosaro 6.5 fl oz/A & Induce 0.125%; 3) *Bacillus subtilis* TrigoCor ca. 1.5 x 10^{14} cfu/A & Induce 0.125%; and 4) TrigoCor & Prosaro & Induce. Application was made with paired Twinjet nozzles mounted at an angle (30° from horizontal) forward and backward and calibrated to deliver at 20 gallons per A. FHB and foliar diseases were assessed at soft dough stages. Grain was harvested from a 4 ft wide x 20 ft long area in each subplot using a Hege plot combine. Grain moistures, plot yields, and test weights were recorded and the latter two were adjusted for moisture. Means were calculated and subjected to Analysis of Variance. Fisher's protected LSD was calculated at P=0.05. Analysis of DON content in grain was conducted in the USWBSI-supported mycotoxin laboratories of Dr. Dong in 2007 and Dr. Schmale in 2008.

RESULTS AND DISCUSSION

Though varying in yield potential, the four experimental environments in New York had in common very low pressure from FHB and foliar diseases due to dry conditions from pre-flowering through early grain filling periods. FHB incidences at soft dough were at 1% or less, yet detectable levels of DON were recorded for some plots in three of the experiments as a result of infection late during grain development. In the virtual absence of foliar/spike disease, no foliar spray treatment (fungicide, biological control, or combination) alone or in interaction with cultivar had a significant effect on yield, test weight, or DON content of grain. Leaf rust on the flag leaves in the late-planted experiment in 2008 was nearly eliminated by application of Prosaro, yet there was no significant effect of this late rust control on yield. A continuing challenge to the implementation of integrated management strategies is that some of the highest yielding regional cultivars are not resistant to FHB. Such is the case with the soft white winter wheat cultivar 'Caledonia' which out-yielded the moderately resistant cultivars in three of the four 'low disease' experiments in New York (Table 1). There was a marginally significant effect of cultivar on DON in two experiments though the contrast is between red and white cultivars rather than susceptible vs. moderate resistance to FHB within market class (Table 2). It is hard to extrapolate from these results, as the levels of toxin were quite low.

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DISCLAIMER

Table 1. Main effect of wheat cultivar on grain yield under four low disease environments at Aurora, NY.

	Adjusted grain yield (bu/A)				
Wheat cultivar:	Expt 1 - 2007	Expt 2 – 2007	Expt 3 – 2008	Expt 4 – 2008	
Planted after >	Tilled soy	No-till corn	No-till soy	No-till corn	Average
Caledonia (Susc., SWW)	70.0	53.4	100.1	85.3	77.2
Freedom (Susc., SRW)	63.4	56.9	82.8	78.6	70.4
Jensen (Mod. Res., SWW)	60.8	50.5	78.7	71.9	65.5
Truman (Mod. Res., SRW)	61.3	50.0	72.1	69.5	63.2
LSD (*P*=0.05)	4.6	NS	3.9	4.6	

Table 2. Main effect of wheat cultivar on deoxynivalenol contamination under four low disease environments at Aurora, NY.

	Contamination of grain by DON (ppm)				
Wheat cultivar:	Expt 1 - 2007	Expt 2 – 2007	Expt 3 – 2008	Expt 4 – 2008	
Planted after >	Tilled soy	No-till corn	No-till soy	No-till corn	Average
Caledonia (Susc., SWW)	0.01	0.26	0.16	0.40	0.21
Freedom (Susc., SRW)	0.00	0.02	0.17	0.16	0.09
Jensen (Mod. Res., SWW)	0.01	0.28	0.20	0.36	0.21
Truman (Mod. Res., SRW)	0.01	0.03	0.20	0.10	0.08
LSD (*P*=0.05)	NS	0.19	NS	0.20	

EFFECTS OF FUNGICIDE TREATMENTS AND CULTIVARS ON FHB AND DON IN WINTER WHEAT.

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ABSTRACT

Fusarium head blight (FHB) is a destructive disease of wheat. In addition to lowering yield and grain quality, the causal fungus, *Fusarium graminearum*, also produces the mycotoxin deoxynivalenol (DON) which poses potential food and feed safety hazards. Integrating cultivar resistance and fungicide application is more effective in managing FHB than either strategy used alone. The objective of this study was to determine the effects of fungicide application and cultivar resistance on FHB and DON in winter wheat. Three cultivars differing in levels of resistance to FHB were planted following corn in the fall of 2007 at the University of Nebraska Agricultural Research and Development Center near Mead, NE. The cultivars were 2137 (susceptible), Jagalene (moderately susceptible), and Harry (moderately resistant). In the spring of 2008, corn kernels colonized by *F. graminearum* were applied to the soil surface in the wheat plots one week before flowering at a rate of 50 g/m^2. There also was plenty of natural inoculum. Plots were not irrigated. The experimental design was a split plot in randomized complete blocks with six replications. Cultivars were the main plots and fungicide treatments (non-treated or treated with Prosaro at 6.5 fl. oz/acre + Induce non-ionic surfactant at 0.125% v/v) were the subplots. Plot size was 5 ft x 20ft. A CO$_2$-powered backpack sprayer and four Teejet 800-1 VS nozzles spaced 12 in. apart on a boom were used to apply fungicide to heads at full heading. Fungicide was applied on June 3. Disease severity and incidence were assessed on 50 randomly selected heads in each plot on June 14, June 20, and June 30 and used to calculate disease index. Severity of Septoria leaf blotch, the predominant foliar disease, was assessed on June 14. Plots were harvested with a small plot combine, which provided yield data. The percentage of *Fusarium*-damaged kernels (FDK) was measured by an automated single-kernel near-infrared system at the USDA ARS Grain Marketing and Production Research Center in Manhattan, KS. A grain sample from each plot was ground and sent to the North Dakota Veterinary Diagnostic Laboratory at North Dakota State University, Fargo, ND for DON determination. Excessively wet weather favored development of severe FHB. Differences in disease index among cultivars were highly significant (P <0.0001) on all three rating dates. Disease index in Harry was lower (*P* = 0.05) than that in either Jagalene or 2137. Jagalene had a higher disease index than 2137, but this difference was mostly non-significant at *P* = 0.05. Fungicide application did not reduce FHB index. This may have been due to high disease pressure. Disease index on June 14 was 14, 11, and 6% for Jagalene, 2137, and Harry, respectively, in the non-sprayed treatment and 13, 10, and 5% for Jagalene, 2137, and Harry, respectively, in the Prosaro treatment. Severity of Septoria leaf blotch on June 14 was 51, 29, and 23% for Jagalene, 2137, and Harry, respectively, in the non-sprayed treatment and 28, 12, and 7% for Jagalene, 2137, and Harry, respectively, in the Prosaro treatment. In the check treatment, yield of Jagalene (14 bu/A) was lower (*P* = 0.05) than that of 2137 (37 bu/A) or Harry (29 bu/A). Yield in the Prosaro treatment was higher (Jagalene, 18 bu/A; 2137, 48 bu/A; Harry, 36 bu/A) than that in the check treatment in all three cultivars, but the difference was not significant at *P* = 0.05. In the check treatment, FDK (47%) and DON (10 ppm) in 2137 were lower (*P* = 0.05) than in Jagalene (61% FDK, 15 ppm DON) and Harry (57% FDK, 14 ppm DON), but did not differ between Jagalene and Harry. In the Prosaro treatment, FDK (34%) and DON (8 ppm) in 2137 were lower (*P* = 0.05) than in Jagalene (51% FDK, 13 ppm DON) and Harry (50% FDK, 14 ppm DON), but did not

differ between Jagalene and Harry. FDK in the Prosaro treatment was lower (*P* = 0.05) than in the check treatment for Jagalene and 2137, but not for Harry. DON concentration in the Prosaro treatment was lower (*P* = 0.05) than in the check treatment for Jagalene, but not for 2137 and Harry. The winter wheat cultivars in this study differed in their reaction to FHB. Although fungicide application did not reduce FHB index, it reduced FDK and DON in some cultivars. Harry, with a moderately resistant reaction to FHB, accumulated more DON than the susceptible 2137. Therefore, some cultivars with a level of resistance to FHB may be susceptible to DON accumulation. Both DON accumulation and reaction to FHB should be considered when selecting cultivars.

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THE 2008 FUSARIUM HEAD BLIGHT EPIDEMIC IN NEBRASKA.

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ABSTRACT

In 2008, Fusarium head blight (FHB) occurred for the second straight year in Nebraska wheat fields. Infection of wheat heads by *Fusarium graminearum* was favored by excessive rainfall before and during flowering. The disease was initially found on June 6 in a grower's field in Lancaster County and in research plots at the University of Nebraska Agricultural Research and Development Center (ARDC) near Mead in Saunders County. The most affected areas were the south central and eastern parts of the state. However, FHB was observed as far west as Imperial in the southwestern part of the state where irrigated fields were more severely affected. Northwest, the Nebraska Panhandle was spared due to dry conditions. A shift towards reduced tillage or no-till to conserve water and soil and inclusion of corn and wheat in crop rotation schemes has led to buildup of FHB inoculum in Nebraska over the last one to two decades. However, because of a variable climate, including drought during some years, FHB has been sporadic in the state. In 2008, as in 2007, above-normal rainfall occurred in south central and eastern Nebraska during the growing season. Heavy rainfall before and during flowering led to outbreaks of severe FHB epidemics. Yields were reduced not only by FHB but by other foliar diseases favored by wet weather. The major foliar diseases were Septoria leaf blotch, powdery mildew, and tan spot. In addition to reducing yield and grain quality, FHB caused accumulation of the mycotoxin deoxynivalenol (DON) in grain. Losses of up to 20% were estimated in the most severely affected areas in the south central and eastern parts of the state. The overall loss statewide in grain yield was estimated at 2.3% or 1.64 million bushels valued at $13.3 million based on an August 28, 2008 wheat price of $8.11/bushel. However the real losses may have been in reduced prices for the infected grain with high levels of DON. In the most severely affected areas, DON concentrations of more than 18 ppm were recorded in the most susceptible cultivars. There were discounts of up to $5/bushel due to DON. In an experiment at the ARDC where wheat heads were grouped into different categories of FHB severity ranging from 0% to 90% in three winter wheat cultivars, DON concentrations ranged from 25 to 57 ppm in the highest severity category. Some growers were reluctant to apply fungicides at flowering because they had already sprayed earlier in the growing season to control foliar diseases and hoped the earlier spray would not require a second fungicide application. However, the fungicides most commonly used to control foliar diseases (Headline, Quilt, and Stratego) do not reduce FHB, hence the damage in fungicide treated fields was also severe. Some growers who wanted to spray with ground equipment were unable to do so because heavy rainfall coincided with flowering. To reduce losses from FHB, growers have been advised to i) plant fungicide treated seed to prevent seedling blights caused by *F. graminearum*, ii) avoid planting wheat after corn or wheat and instead plant wheat after a broadleaf crop such as soybean, iii) select cultivars with good resistance or tolerance to FHB and DON, iv) plant several cultivars that differ in flowering dates to increase the chances that some cultivars will escape infection, v) use the national Fusarium head blight prediction tool to assess the risk of FHB development, and vi) apply an appropriate fungicide at early flowering based on the predicted risk of an FHB outbreak. The severe epidemics of 2007 and 2008 are testimony to the fact that although Fusarium head blight

is sporadic in Nebraska due to a variable climate, it can be devastating when it occurs. Concerted efforts are under way to educate growers, crop consultants, extension personnel, and others involved in the wheat industry about FHB and how to manage it.

EFFECTS OF TEMPERATURE ON DEOXYNIVALENOL TRANSLOCATION AND *F. GRAMINEARUM* INFECTION OF WHEAT HEADS.

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ABSTRACT

The primary causal agent of Fusarium Head Blight in North America is *Fusarium graminearum*. This fungus is known to infect wheat during the flowering and grain-filling stages of development. Shortly after infection, the fungus produces mycotoxins, including deoxynivalenol (DON), which contaminate floral tissue and grain. However, the relationship between mycotoxin levels and fungal infections of wheat heads is not fully understood, in light of the fact that DON can be translocated through the plant. The objective of this research was to study the effects of temperature on fungal biomass and translocation of DON within infected wheat heads. Two spring wheat cultivars were used in this study: Alsen (moderately resistant) and Wheaton (susceptible). A central spikelet was inoculated with macroconidia during mid-anthesis and plants were then incubated at 15 or 22°C. Single spikelets were harvested on days 2, 3, 4, 6, 8, 10 and 12 following inoculation. One floret from each spikelet was placed on Nash agar to establish the presence of *F. graminearum*. DON and ergosterol, a fungal biomass indicator, were extracted from the other floret. DON was extracted using 84:16 acetonitrile-water, while ergosterol was extracted with hexane through a saponification step with methanolic potassium hydroxide. The extracts were combined and a single gas chromatography method was used to detect both compounds. Preliminary results revealed heads of both wheat cultivars were fully colonized with *F. graminearum* by 12 days post-inoculation, regardless of incubation temperature. By 3 days post-inoculation, *F. graminearum* had yet to colonize spikelets beyond the inoculated point in either wheat cultivar. Yet DON translocation to spikelets not colonized by the pathogen was observed at 2 days post-inoculation. DON production also appeared to be stimulated when the fungus was stressed by low temperatures (15°C) or host resistance, possessed by Alsen. Through this research, we have confirmed our methods of DON and ergosterol extraction and detection to be sensitive and effective for point-inoculated wheat heads. We have confirmed the ability of DON to translocate to parts of the wheat head not previously colonized by *F. graminearum*. Results also suggest DON production is a mechanism the fungus uses to adapt to challenging environmental conditions. These findings may, in part, explain the development of asymptomatic grain and help to characterize the complex relationship between DON and disease intensity.

BIOLOGICAL CONTROL OF SCAB: HOW CLOSE ARE WE TO REALITY?

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ABSTRACT

A taxonomically diverse group of microbial agents that includes strains of bacteria and yeasts has been investigated for potential control of Fusarium head blight and deoxynivalenol accumulation in wheat and barley. Biological control has been attributed to antibiotic production, induced resistance and niche exclusion. Each microbe, when applied to cereal heads, consistently controlled the disease in greenhouse experiments and was effective in reducing disease severity or deoxynivalenol levels in separate field experiments. In addition, biocontrol agent-fungicide combinations were shown in some field experiments to enhance disease control over the application of the biological agents or fungicides alone. Since 2004, uniform multistate evaluations of biocontrol agents have been conducted across different environments and cereal crops. These trials also examined the integration of biological control with fungicides. While biological treatments exhibited promise in some trials, consistent field efficacy has been difficult to achieve with any single agent. Significant strides have been made to identify production and formulation methodologies to enhance field efficacy of some biocontrol agents. Research on the population dynamics of biocontrol agents and the expression of biocontrol mechanisms under field conditions is underway. New commercial biocontrol organisms are being made available for evaluations. These collective efforts may lead to biological control becoming an effective and practical strategy for integration with fungicides and host resistance to manage Fusarium head blight and deoxynivalenol.