SESSION 1:

FHB MANAGEMENT

Co-Chairpersons: Gary Bergstrom and
Gene Milus

EFFECT OF PLANT RESIDUE TREATMENT ON THE EPIDEMIOLOGY OF FUSARIUM HEAD BLIGHT

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ABSTRACT

Kazakhstan is the largest producer of wheat in the central part of Asia. Each year different fungal pathogens cause yield losses from 10-40% in the country. FHB has affected all wheat and barley classes. The disease is caused by the set of *Fusarium* and *Microdohium* species. Integrated disease control in fields includes resistant varieties, cultural practices, and fungicide application. Within the fungicide reduction policy, it's important to develop alternative means to control wheat diseases. In the case of soil borne diseases, the crop residues contribute to the disease severity. Thus, to control FHB epidemics, it's important to suppress the disease by means of reducing pathogens surviving on plant residues. Several *Fusarium* species, esp. *Fusarium graminearum, F.culmorum* were isolated from surface soil, anthesis and plants at dough, and from plant residues after wheat harvest in 2010. The inhibition effect of crushed horseradish (*Armoraceae lapathifolia*) tuber tissue volatiles and active compounds on FHB in two small farms in 2010-2012 years was evaluated. Ground horseradish tuber tissue (100 g/10 plant residues) was spread onto wheat residues in October 2010-2011. Every year the occurrence of FHB during the vegetation season was monitored. Plots repeatedly treated with horseradish every year in October had significantly reduced FHB up to 50%. Commercial fungicides or tuber tissue of different plants (carrot, potato) failed to reduce FHB and *Fusarium* inoculum in plant residues and soil. Populations of *Streptomyces* spp., *Bacillus* spp., *Pseudomonas* spp. in soil after the plant tuber tissue amendment gradually expanded (7-fold in 2012) in comparison with those ones in nontreated plots. This approach has the potential to reduce FHB to acceptable level.

DETERMINING 'RAIN FAST' TIME AND RESIDUAL LIFE OF PROSARO ON WHEAT SPIKES

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ABSTRACT

Fusarium head blight (FHB) is a disease of wheat and other small grain crops caused by the fungal pathogen *Fusarium graminearum* (teleomorph, *Gibberella zeae).* Chemical control has become an important component of FHB management practices and, when applied correctly, can reduce FHB and as well as its associated toxin, Deoxynivalenol (DON). Rainfall events surrounding anthesis are most conducive to FHB development and DON accumulation and thus it is under these conditions that fungicide application is most warranted. It is unclear, however, how rainfall directly following application of certain fungicide chemistries affects deposition, coverage, absorption and efficacy. The aim of the current study was to determine the 'Rain Fast' time for Prosaro® (tebuconazole + prothioconazole). A field trail was conducted for the first time during the 2011/12 growing season in Wooster, OH. A moderately susceptible cultivar (cv. Hopewell) was used in a randomized complete block design with five simulated rainfall treatments applied at different times after a single application of Prosaro® (6.5 fl. Oz/A + 0.125% Induce v/v) at anthesis; no rainfall (1) rainfall 60 minutes after application (2), rainfall 105 minutes after application (3), rainfall 150 minutes after application (4), and rainfall 195 minutes after application (5). Rainfall treatments were applied using an artificial rain simulator, at an intensity of approximately 39 mm/h, for 6 minutes. Plots were spray inoculated with *F. graminearum* spore suspensions approximately 12 hours after fungicide application. Fungicide residue on wheat spikes over time was quantified by collecting a sample of spikes from each plot every four days after fungicide treatment application and analyzing for Tebuconazole residue using GC-MS. FHB intensity was rated approximately 3 weeks after anthesis and DON was quantified post-harvest. In general, rainfall closer to fungicide application (60, 105 and 150 minutes after) reduced fungicide efficacy, resulting in higher mean FHB intensity and DON than later rainfall (195 minutes) or no rainfall (0). Rapid decrease in Tebuconazole residue was seen after 7 days in all treatments, and the rate of decrease appeared to be similar among rainfall timings. This study will be repeated in the 2012/13 growing season using a similar protocol.

EFFECTS OF LOCAL CORN DEBRIS MANAGEMENT ON FHB AND DON LEVELS IN FOURTEEN U.S. WHEAT ENVIRONMENTS IN 2011 AND 2012

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ABSTRACT

Reduction or elimination of within-field sources of inoculum of *Fusarium graminearum* is the basis for cultural control measures such as crop rotation sequences in which cereals follow non-cereal crops. In USWBSI-supported microplot experiments conducted in twenty-one winter wheat fields over five states in 2009 and 2010, DON level differed significantly between corn debris and no debris microplots in only one location, strongly suggesting that regional atmospheric inoculum is the strongest contributor to infection even when corn debris is present in a wheat field. Small area sources of debris, however, may result in an underestimation of the contribution of spores from a larger field of corn debris to FHB and DON. The goal of the current USWBSI research project is to provide realistic estimates of 'DON reduction' that can be expected from cultural controls that reduce within-field inoculum sources. We utilized moldboard plowing of corn debris as a proxy for planting after a non-cereal crop to compare directly with wheat planted no-till into corn debris in commercial-scale wheat fields planted following grain corn harvest in Illinois, Kentucky, Michigan, Missouri, Nebraska, New York, and Vermont. Following corn harvest, replicated wide (60 ft) strips were moldboard plowed or left non-plowed prior to sowing wheat over the entire field with a no-till drill. Wheat in each strip was monitored for FHB and sampled for laboratory quantification of head infection by *F. graminearum* and contamination of grain by DON. Results were collected over two years, 2011 and 2012, from winter wheat in six states (IL, KY, MI, MO, NE, and NY) and spring wheat in one state (VT).

In 2011, FHB symptoms at soft dough stage were low to moderate at every location except Missouri. Yet, at crop maturity, a high percentage of wheat heads was found to be infected by *F. graminearum* in all locations except Nebraska and Vermont. Measurable DON was found in grain from every environment and the levels were lowest in Vermont and highest in Kentucky and Nebraska. It is interesting that the Nebraska site showed the lowest disease index and lowest incidence of head infection, but the highest average toxin level. Moldboard plowing resulted in a significant decrease in FHB index in four environments (IL, MO, NY, MI), though the magnitude of the difference was large only in Missouri. In Nebraska, FHB index was significantly higher in the moldboard-plowed treatment in which the wheat crop matured earlier than in the no-till corn debris treatment. Moldboard plowing was associated with a small but significant decrease in recovery of *F. graminearum* from mature heads in three environments (IL, MI, NY). There was no significant effect of plowing on DON level in five environments (IL, KY,

MO, NY, VT) and there were small but significant decreases in toxin in moldboard-plowed compared to no-till strips in two environments (MI and NE). An additional treatment of minimum tillage (chisel plow) was added in the Michigan experiment; DON levels in the minimum-till plots were intermediate between moldboard and no-till but not significantly different from no-till.

In 2012, a generally warm and dry cropping season across the experimental region, FHB symptoms at soft dough stage were not observed in four locations (KY, MI, NY, VT) and were observed at low levels at three locations (IL, MO, NE); plowing had no significant effect on FHB index in any location. At crop maturity, a moderate percentage of wheat heads (i.e., greater than 10%) was found to be infected by *F. graminearum* only in Missouri and Vermont; in both environments there was a significantly greater incidence of heads infected in no-till than in moldboard-plowed strips. DON was not detected in Nebraska, and was detected at low levels in all other states. Moldboard plowing resulted in a significant decrease in already low DON levels in New York and Vermont. A similar level of reduction in DON level was observed in wheat from moldboard-plowed strips in Michigan, but DON was assayed in small samples that were pooled from the replicate strips, so no statistical comparison could be made.

There is a strong trend in two years of data suggesting that inoculum from area atmospheric sources exerts a far greater effect than inoculum from in-field corn residue on the level of DON contamination. A third year of experimentation in three additional wheat environments in 2013, in Illinois, Nebraska and New York, will provide increased evidence of the magnitude of the effect of corn residue management on DON reduction.

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2012 TRIAL OF THE PERFORMANCE OF SELECTED BIOLOGICAL CONTROL AGENTS FOR THE SUPPRESSION OF FUSARIUM HEAD BLIGHT IN SOUTH DAKOTA AND NORTH DAKOTA

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ABSTRACT

Fusarium Head Blight (FHB) or Wheat Scab, caused by *Fusarium graminearium (Gibberella zeae*) is an economically important disease of wheat and barley. Yield losses could be controlled or reduced through the use of fungicides alone or in combination with biological control agents (BCAs). Field plot trials were conducted in Brookings, South Dakota and Langdon, North Dakota to analyze the efficacy of *Bacillus* strains in biological control of FHB. Spray applications of *Bacillus* BCAs alone or in combination with Prosaro® (fungicide) and/ or Induce NIS (non-ionic surfactants) and/ or colloidal chitin, and/or plant oil were done on Durum and Briggs spring wheat heads at Feekes 10.51. In the Brookings spring wheat trial, the combination of *Bacillus* 1BA, plant oil and Prosaro® reduced the FHB incidence to 5.5%, which was less than the FHB incidence observed for Prosaro alone (6.5%) or the untreated control (16.5%). Treatments of *Bacillus* 1BA with plant oil and Prosaro reduced the disease index to 0.76%, while the treatment *Bacillus* 1D3 + plant oil + colloidal chitin + Prosaro reduced it to 0.74%. Treatment of Prosaro alone reduced the FHB disease index to 0.93%, while for the untreated control it was observed to be 2.74%. Treatment differences were observed for Disease DON (deoxynivalenol), Disease FDK and Disease Protein as well. In the Langdon durum wheat trial, treatment differences were observed for FHB incidence, severity, index, yield and test weight. These trials demonstrated that *Bacillus* strains 1BA or 1D3 in combination with Prosaro and/or colloidal chitin and/or plant oil can reduce FHB incidence and FHB disease index in wheat, more than a single application of Prosaro.

INFLUENCE OF MANAGEMENT PRACTICES ON *FUSARIUM* MYCOTOXINS IN WHEAT STRAW

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ABSTRACT

The effect of foliar fungicides and resistant cultivars have been evaluated for their effects on mycotoxins in grain associated with Fusarium head blight (FHB) of wheat; however, little is known about how these FHB management practices affect mycotoxins in wheat straw. High mycotoxins levels in wheat straw could be a serious problem for livestock producers who use wheat straw for bedding in their facilities. This could be most detrimental to non-ruminant animals such as swine sows, which can eat 2 to 4 kg of wheat straw bedding per day. Research trials were conducted in 2011 and 2012 in Illinois to determine mycotoxin levels present in wheat straw (stems only) and if typical FHB management practices had an effect on mycotoxin levels. To determine the mycotoxin levels, stem samples were collected immediately after harvest, were ground into small particles, and then sent to the University of Minnesota mycotoxin testing laboratory.

Fungicide trials were conducted at four locations in Illinois (Brownstown, Dixon Springs, Monmouth, and Urbana) to determine the effects of Headline® (pyraclostrobin; BASF Corp.), Caramba® (metconazole; BASF Corp.), Prosaro® (prothioconazole + tebuconazole; Bayer CropSciences), and Folicur® (tebuconazole; Bayer CropSciences) on mycotoxins in wheat straw. All locations were planted into corn stubble and were mist-irrigated. Headline was applied at Feekes growth stage (FGS) 9, while all other fungicides were applied at FGS 10.5.1. Ranges of DON, 3ADON, 15ADON, NIV, and ZEA in wheat stems at these locations were 0.6-104.6 ppm, 0.01-5.7 ppm, 0.1-17.8 ppm, 0-1.6 ppm, and 0-1.3 ppm, respectively in 2011, and 1.1-13.3, 0-0.5, 0.2-3.2, 0-0.3, and 0-0.2 ppm, respectively in 2012. In 2011, when averaged over all locations, none of the fungicides decreased mycotoxin levels compared to the non-treated control, but Headline fungicide significantly ($P \leq 0.10$) increased 3ADON and 15ADON compared to the non-treated control. In 2012, when averaged over all locations, none of the fungicides significantly decreased or increased mycotoxins compared to the non-treated control.

Integrated management trials designed to evaluate cultivar (susceptible vs. moderately-resistant) × fungicide (Prosaro vs. non-treated) effects were conducted at Dixon Springs, Urbana, and Monmouth, IL. Two trials (mist-irrigated and non-irrigated) were conducted at Urbana each year. Ranges of DON, 3ADON, 15ADON, NIV, and ZEA in these trials were 0.1-33.5, 0-1.39, 0-10.1, 0-0.5, and 0-1.5 ppm, respectively in 2011, and 0.2-10.0, 0-0.6, 0-2.2, 0-1.1, and 0 ppm, respectively in 2012. When averaged over all trials in 2011, foliar fungicides did not affect mycotoxin levels, but the susceptible cultivar (Pioneer 25R47) had significantly greater DON levels compared to the moderately resistant cultivar (BW5228). When averaged over all trials in 2012, no significant differences were observed among any of the treatments for mycotoxins levels in the wheat stems.

A mist-irrigated cultivar evaluation trial was conducted at Urbana in 2011 and 2012. Ranges of DON, 3ADON, 15ADON, NIV, and ZEA at these locations were 8.9-54.1, 0.6-3.1, 4.9-16.6, 0, and 0-0.5 ppm, respectively in 2011, and 0.3-6.0, 0-0.5, 0.2-2.1, 0-0.7, and 0 ppm, respectively in 2012. In 2011,

significant differences in levels of DON, 3ADON, and 15ADON were observed among the cultivars, and a significant, positive Spearman correlation (*P* = 0.0001; *R* = 0.50) was detected between DON levels in straw and DON levels in grain. In 2012, no significant differences in stem mycotoxin levels were observed among cultivars, but a significant, positive Spearman correlation (*P* = 0.0132; *R* = 0.36) was detected between DON levels in straw and DON levels in grain. The significant correlations detected between DON in grain and DON in straw indicates that a cultivar's FHB resistance level may play a role in the level of DON observed in the straw.

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EFFICACY OF CLO-1 BIOFUNGICIDE ON SUPPRESSING PERITHECIAL PRODUCTION OF *GIBBERELLA ZEAE* ON CROP RESIDUES

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ABSTRACT

Fusarium head blight (FHB), caused by *Gibberella zeae*, is a destructive disease of wheat. Previous studies demonstrated that *Clonostachys rosea* strain ACM941 is a *G. zeae* antagonist by inhibiting mycelial growth and reducing FHB severity. The objective of this research was to evaluate the efficacy of CLO-1, a formulated product of ACM941 for reducing perithecial production on various crop residues in comparison with registered fungicide Folicur (tebuconazole) under field conditions. When applied on *G. zeae* inoculated corn, soybean and wheat residues in spring each year of 2009 and 2010, CLO-1 significantly inhibited the perithecial production on all the crop residue types, reducing daily perithecial production (DPP) by 89.4% on corn residue, 92.2% on soybean residue and 88.6% on wheat residue, compared with the untreated control. When applied on naturally infected wheat residues in the fall each year of 2009 and 2010, CLO-1 significantly reduced DPP in the following growing season by 72.3% on peduncle, 51.0% on spikelet, and 57.2% on stem. These effects were better but not significantly different from those achieved by Folicur fungicide used as positive control in the same experiments. Results of this study suggest that CLO-1 is a promising biofungicide against *G. zeae* and may be used as a control measure in an integrated FHB management program to reduce the initial inoculum, and thus reduce FHB severity and increase yield and grain quality.

KNOWN KNOWNS AND KNOWN UNKNOWNS: ASSESSING ADOPTION OF SCAB MANAGEMENT TOOLS

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ABSTRACT

Over the past two decades, researchers have developed and disseminated recommendations for management of Fusarium head blight of wheat in the U.S. Of several recommendations, the three key ones are: increase acreage of moderately resistant varieties; monitor scab risk leading up to heading and flowering; and, when indicated, make a timely application of an effective fungicide. Use of these techniques has been demonstrated to significantly reduce kernel abortion, kernel damage, and mycotoxin contamination.

From anecdotal evidence, it appears that wheat grower adoption of these techniques is uneven. This suggests the need for: 1) a more systematic assessment of the extent of adoption in scab-prone areas, and 2) a deeper understanding of factors that hinder or promote adoption.

In an initial inquiry, two available sets of data on adoption were evaluated.

The first dataset was of subscriptions to the USWBSI-supported system of email and/or text message alerts. These alerts are received free of charge when advisory updates are posted to the scab risk forecasting web site. Data on subscribers consisted of state, occupation, and type of alert received. As expected, the five largest categories of subscribers were farmers, fungicide industry, grain purchasers, consultants, and extension personnel. States with the largest number of subscriptions tended to have a high percentage of farmers as subscribers. Subscriptions per 1,000 wheat farms ranged from one to 22, and varied substantially among states.

The second dataset was of 2011 acreage by variety. Those data were assessed together with ratings of commonly planted wheat varieties for 21 states that are covered by USWBSI scab risk forecasts, have significant wheat acreage, and are subject to scab epidemics. Among the results:

- In five states that produce hard wheat and durum wheat, estimates were made for an area covering over 22 million acres of wheat planted annually by about 57,000 wheat farming operations (National Agricultural Statistics Service, or NASS). Annual variety surveys by state and market class allowed estimation of percentages of acreage planted to specific wheat varieties. FHB resistance ratings for those varieties were used to classify the varieties as moderately resistant (MR), moderately susceptible (MS), or susceptible (S). The MR percentage estimates ranged from 0 to 62 and indicated where major progress has been made in breeding and growing scab-resistant varieties.

- By contrast, out of 16 scab-vulnerable states that primarily grow soft wheat, only one had published a recent survey of wheat variety acreage that allowed estimation of percentages of MR, MS, and S cultivars. In this 16-state soft wheat area, about 6.36 million acres of wheat were planted annually by about 61,300 wheat farms, according to NASS. In addition, rough estimates of market shares

of top varieties were obtained for some soft wheat states from private consultants, seed producers, and seed certification agencies.

The data suggest that major progress has been made in adoption of recommended scab techniques in some areas. It also appears there is a need for new systems to regularly obtain estimates of variety acreage in the primarily soft-wheat states. Such information would allow a stronger focus on adoption of variety resistance, and would permit monitoring of progress to occur. The data also suggest that lessons could be learned from states that have been especially successful in raising awareness and use of scab risk forecasts among growers and their advisors.

EVALUATION OF INTEGRATED METHODS FOR MANAGING FHB AND DON IN WINTER WHEAT IN NEW YORK IN 2012

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OBJECTIVE

To evaluate the individual and interactive effects of moderately resistant cultivars and the foliar fungicide Prosaro® on wheat yield and the integrated management of Fusarium head blight (FHB) and deoxynivalenol (DON) under two 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 2012, we observed the disease and yield impact of cultivar susceptibility, inoculation with *Fusarium graminearum*, and treatment with Prosaro fungicide in two different experimental environments.

MATERIALS AND METHODS

Both experiments were performed at the Musgrave Research Farm in Aurora, NY following cultural practices recommended for soft red winter wheat in the region. The four cultivars included were 'Pioneer 25R34' (classified as moderately susceptible to FHB), 'Pioneer 25R46' (classified as moderately resistant to FHB), 'Otsego' (classified initially as moderately resistant to FHB), and 'Truman' (established as moderately resistant to FHB). The two experimental environments, both planted on September 26, 2011, were characterized by the planting of winter wheat no-till into 1) soybean residue and 2) corn residue in immediately adjacent parcels of land. Each experimental design was a split-split plot with four wheat cultivars as whole plots, inoculation treatment as subplot, and fungicide treatment as sub-subplot, in four replicated blocks. Main plots were planted with a 10 ft wide commercial grain drill and were 20 ft long. Spray treatments applied at Feekes GS10.5.1 on 5/23/12 were 1) non-sprayed, non-inoculated 2) Prosaro 6.5 fl oz/A & Induce 0.125%, non-inoculated 3) non-sprayed and inoculated with *F. graminearum*; and 4) Prosaro 6.5 fl oz/A & Induce 0.125% and inoculated with *F. graminearum*. Treatments 3 and 4 were inoculated with a conidial suspension of *F. graminearum* (40,000 conidia/ml) on the same day as the Prosaro application after the fungicide had dried and in early evening to provide a better environment for infection. Prosaro and *F. graminearum* applications were applied with a tractor-mounted sprayer with paired Twinjet nozzles mounted at an angle (30^o 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 on July 3, 2012. Grain moistures, plot yields, and test weights were recorded with the latter two 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 laboratory of Dr. Dong.

RESULTS AND DISCUSSION

Both experimental environments were located in the same field that in the previous year was split, growing corn in one half and soybean in the other. Flowering occurred simultaneously in both environments during a relatively dry period, considered low risk for FHB infection. FHB incidence at soft dough stage was well below 1% in all plots so was recorded as zero.

The impact of *F. graminearum* inoculation was determined by comparing the non-inoculated and inoculated treatments (combining non-sprayed and Prosaro treatments) in both experiments (environments). Inoculation did not significantly affect yield, FHB index, or DON in either experiment. Cultivars did not respond differentially to inoculation in either environment.

Significant differences in yield were detected among cultivars in each environment. Following soybean, only Otsego had significantly higher yield than that of all other cultivars. Following corn, Otsego had the highest yield, which was significantly higher than Pioneer 25R34 and Pioneer 25R46; and Pioneer 25R34 had the lowest yield, which was significantly lower than Otsego and Truman. Yield for each cultivar was significantly higher following soybean than following corn. This may be attributable to increased nitrogen following soybean, but this was not measured. However, within each environment, there was no significant difference in yield within each cultivar, regardless of spray treatment or inoculation, except for the non-inoculated, non-sprayed P25R34. For some unknown reason this treatment resulted in a yield significantly lower than all other treatments for this variety. In the virtual absence of disease pressure, cultivars differed significantly in yield with Otsego consistently yielding highest.

When results of all the cultivars were combined, the overall impact of the Prosaro applications was not significant, regardless of environment, for yield or FHB index. No significant difference was detected for DON contamination among any of the spray treatments in either environment. The only significant difference in DON contamination of grain was for the cultivar Pioneer 25R34, which although still far below the threshold of agronomic importance, i.e., 2 ppm, was significantly higher than that of the other varieties following corn. In this experiment, with little to no fungal disease pressure, the Prosaro application caused no significant improvement of yield or reduction in FHB index or DON contamination of grain.

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Table 1. Main effect of treatment on grain yield, Fusarium head blight index, and deoxynivalenol contamination at Aurora, NY.

	Adjusted grain yield (bu/A)		
Treatment:	After corn	After soybean	Average
Non-sprayed, non-inoculated	90	123	107
Prosaro, non-inoculated	89	124	107
Non-sprayed, inoculated	90	129	110
Prosaro, inoculated	92	127	110
LSD (*P*=0.05)	NS	NS	
	Fusarium head blight index (%)		
Treatment:	After corn	After soybean	Average
Non-sprayed, non-inoculated	0	0	0
Prosaro, non-inoculated	0	0	0
Non-sprayed, inoculated	0	0	0
Prosaro, inoculated	0	0	0
LSD (*P*=0.05)	NS	NS	
	Contamination of grain by DON (ppm)		
Treatment:	After corn	After soybean	Average
Non-sprayed, non-inoculated	0.05	0.02	0.04
Prosaro, non-inoculated	0.06	0.03	0.05
Non-sprayed, inoculated	0.04	0.04	0.04
Prosaro, inoculated	0.05	0.03	0.04
LSD (*P*=0.05)	NS	NS	

Table 2. Main effect of cultivar on grain yield, Fusarium head blight index, and deoxynivalenol contamination at Aurora, NY.

	Adjusted grain yield (bu/A)		
Cultivar:	After corn	After soybean	Average
Otsego	101 a	137 a	119
Pioneer 25R34	78 c	124 b	101
Pioneer 25R46	87 bc	125 b	106
Truman	96 ab	118 b	107
LSD (*P*=0.05)	11.5	10.9	
	Fusarium head blight index (%)		
Cultivar:	After corn	After soybean	Average
Otsego	0	0	0
Pioneer 25R34	0	0	0
Pioneer 25R46	0	0	0
Truman	0	0	0
LSD (*P*=0.05)	NS	NS	
	Contamination of grain by DON (ppm)		
Cultivar:	After corn	After soybean	Average
Otsego	0.02 b	0.03	0.03
Pioneer 25R34	0.12 a	0.04	0.08
Pioneer 25R46	0.04 b	0.03	0.04
Truman	0.05 b	0.02	0.04
LSD (*P*=0.05)	0.040	NS	

EVALUATING THE EFFECT OF FUNGICIDE CHEMISTRY AND APPLICATION TIMING ON FHB, DON AND *FUSARIUM GRAMINEARUM* BIOMASS IN SOFT RED WINTER WHEAT

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ABSTRACT

Quinone Outside Inhibitors (QoI) and Demethylation Inhibitors (DMI) are highly effective fungicides against foliar diseases, and as such, are important components of wheat disease management programs. However, while the DMIs are highly recommended for Fusarium head blight (FHB) and deoxynivalenol (DON) control, the QoIs are not. This is largely because some members of the latter group of fungicides have been shown to increase DON in wheat grain, especially when applied close to anthesis. However, it is unclear whether DON response to QoI fungicides is consistent across active ingredients (AIs); whether the response in influence by application timing and weather conditions; and whether it is associated with an increase in fungal colonization of the grain. A field study was conducted in Wooster, OH, to evaluate the effects of two QoI fungicide AIs (Azoxystrobin and Pyraclostrobin), applied at different growth stages, FHB, DON and *F. graminearum* biomass (FBM) in wheat. DMI fungicide treatments were also included as references for comparison with the QoI treatments. The experimental design was a randomized complete block with 9 treatments plus an untreated check. The treatments consisted of Headline® (6 fl. oz./A), Quadris® (9 fl. oz./A), and Prosaro® (6.5 fl. oz./A) applied at Feekes growth stages (GS) 8 (flag leaf emergence), GS 10 (boot), and GS 10.5.1 (flowering). A nonionic surfactant was added to each treatment at a rate of 0.125% v/v. All plots were spray-inoculated with a spore suspension of F. graminearum approximately 24 h after the anthesis treatments were applied. FHB intensity was rated approximately three weeks after anthesis, and a sample of grain from each plot was visually rated for *Fusarium* damaged kernels (FDK) and analyzed for DON and fungal biomass (*Fusarium* infection) using gas chromatography-mass spectrometry and quantitative real-time PCR laboratory techniques. The highest levels of DON and fungal biomass (FBM) were observed in the QoI treatments (AI x timing combination), with two of those treatments (Quadris at Feekes GS 8 and GS 10) being significantly different from the untreated check for DON contamination and one (Quadris at GS 10) significantly different from the check for fungal biomass. However, the levels of FHB index and FDK in the Quadris GS 8 and Quadris GS 10 treatments were not significantly different from the untreated check, suggesting that relative to the check, these two treatments resulted in disproportionately higher levels of DON contamination and fungal colonization of the grain than expected based on visual symptoms. This was confirmed by the fact that these same two treatments had significantly lower index:DON, FDK:DON, and index:FBM ratios than the untreated check.

BOOSTED REGRESSION TREES IDENTIFY PRE- AND POST-ANTHESIS WEATHER VARIABLES FOR PREDICTING FUSARIUM HEAD BLIGHT EPIDEMICS

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ABSTRACT

The project's goal was to identify weather variables useful for predicting major Fusarium head blight (FHB) epidemics in the United States. The dataset consisted of 527 unique observations of major (severity ≥ 10%) and non-major (severity < 10%) epidemics, linked to 380 weather-based predictors summarizing temperature (t), relative humidity (rh) or rainfall (r) in fixed-length windows pre- and post-anthesis; as well as binary indicators for the level of genetic resistance, the presence of crop residue as a local inoculum source, and the type of wheat (winter vs. spring wheat). Boosted Regression Trees (BRTs) were fit to a subset consisting of 70% of the data, and model test error was estimated on the remaining 30% of the data. The BRT models have deepened the understanding of how variables are associated with FHB epidemics, and have suggested novel representations of weather that may be more associated with FHB epidemics than predictors now used. BRT models confirmed that rh is an important predictor of major FHB epidemics, but also indicated a greater importance of t and r than previously suggested by earlier modeling approaches. The BRT models also identified variable interactions that were difficult to detect in previous analyses. Results of this analysis will be integrated into existing models for FHB epidemics to improve predictive accuracy.

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FUSARIUM HEAD BLIGHT MANAGEMENT: PROGRESS AND POSSIBLE KNOWLEDGE GAPS

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ABSTRACT

The cooperative effort to improve the management of Fusarium head blight (FHB) within the United States has made several important advances since the beginning of the US Wheat and Barley Scab Initiative (USWBSI). Early advances included an improved understanding of fungicide efficacy for various active ingredients and application technologies that could maximize the value of these products. As varieties with genetic resistance became more widely available, the group began investigating the potential benefits of combining genetic resistance with fungicides for improved FHB control. Advances in disease forecasting models for FHB complimented the integrated management research and help growers evaluate the risk of severe epidemics and the need for fungicide applications. Despite these advances, the management of FHB remains a challenge for many growers because of incomplete information about the FHB reaction of common varieties, and factors that compromise the efficacy of fungicide applications. To address these challenges, we must address these knowledge gaps with a renewed commitment to FHB management research and communication efforts.

ACKNOWLEDGEMENT AND DISCLAIMER

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UNIFORM FUNGICIDE TRIAL RESULTS FOR MANAGEMENT OF FHB AND DON, 2012

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ABSTRACT

Uniform fungicide trials were conducted on multiple classes of wheat (durum, hard red spring, hard red winter, and soft red winter) across six states in 2012. Trials were established at multiple locations in Illinois, North Dakota and South Dakota, and one location in Arkansas, Minnesota and New York. All sites had either added inoculum in the form of *Fusarium graminearum* infested grain spawn, infested residue, or the fungus was spray inoculated at flowering. Several sites used mist or overhead irrigation to promote disease development. Four test sites (Fargo, ND; Ithaca, NY; Fayetteville, AR; and Groton, SD) were too hot and too dry for adequate development of FHB to separate treatments. Twelve site/variety combinations did have adequate FHB for determining efficacy of treatments. Thirteen treatments were evaluated across six of these location/variety sites, while 10 treatments were evaluated across 12 location/variety sites. Treatments included triazole fungicides - Caramba® (metconazole), Prosaro® (prothioconazole + tebuconazole); and Folicur® (tebuconazole) applied alone at Feekes 10.5, 10.5.1 or 5 days after Feekes 10.5.1; and a strobilurin fungicide - Headline (pyraclostrobin) applied alone at Feekes 9.0, or combinations of Headline at Feekes 9 followed by Caramba, Prosaro, or Folicur at Feekes 10.5.1. Sites that had only 10 treatments generally did not include the Caramba or Prosaro applied at Feekes 10.5 or the Headline treatment at Feekes 9. Preliminary examination of the data indicates:

- FHB Index (% Field Severity): Triazole fungicide treatments generally reduced FHB index from that of the untreated. For sites with all 13 treatments, the highest FHB index among fungicide treatments generally was with Headline applied alone, at Feekes 9. For sites that did not have this treatment, the highest FHB index value most frequently observed among fungicide treatments was Headline at Feekes 9 followed by Folicur at Feekes 10.5.1, and lowest values generally with a triazole fungicide applied at Feekes 10.5.1.

- DON (ppm): For sites with all 13 treatments, Headline applied once at Feekes 9 generally had the highest DON level apart from the untreated check. Triazole fungicides applied at Feekes 10.5.1 or five days after Feekes 10.5.1 generally resulted in lowest DON levels across sites.

- Yields ranged from 30+ bu in some hard red spring wheat sites to 80 to 90+ bushels in some Illinois winter wheat sites, and yield responses to treatment varied among sites. When yields were converted to percent of untreated for each trial, average yield responses to fungicides generally ranged from 5 to 35%, but greater responses were observed in MN.

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UNIFORM TESTS OF BIOLOGICAL CONTROL AGENTS FOR MANAGEMENT OF FHB AND DON, 2012

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ABSTRACT

A uniform set of eight biological or biological plus fungicide treatments were compared to an untreated check for evaluation of control of Fusarium Head blight (FHB) and DON (deoxynivalenol) in wheat. Taegro (bacterium *Bacillus subtilis* var. *amyloliquefacians* strain FZB24 containing 5.0 x 1010 cfu/g, Novozymes Biologicals Inc.) was the test biological agent, applied either alone at five to seven days after Feekes growth stage 10.5.1, or following application of a triazole fungicide at Feekes growth stage 10.5.1, and with or without canola oil as an adjuvant. Treatments were applied to soft red winter wheat (Aurora, NY), hard red winter wheat (Mead and Havelock, NE), and hard red spring wheat (Volga, SD). Disease levels were low at the four sites in 2012, because of the occurrence of high temperatures and drought, although each site had either natural inoculum, infested grain spawn, or sprayed inoculum to increase disease potential. FHB Index (% field severity) values were determined at three of the four sites, and were non-significant among treatments at the two NE sites, and generally not significantly different than the untreated check at the SD site. *Fusarium* damaged kernels (FDK) values were not different among treatments. DON levels were below detectable levels at the two NE sites, and less than one ppm for all treatments at the NY and SD sites. Results in NY and SD indicated that DON levels generally were significantly reduced with the triazole fungicide treatments or with Taegro if applied in combination with a triazole fungicide. Yield impacts were non-significant at three locations. At the SD site, yield was lowest in the untreated check, and significantly improved with several fungicide or Taegro plus fungicide treatments.

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BARLEY MONOCULTURE SYSTEM: EFFECT OF TILLAGE PRACTICES ON DEOXYNIVALENOL (DON) CONTENT

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ABSTRACT

Fusarium head blight (FHB) associated with the presence of the fungus *Fusarium graminearum* is probably one of the most feared diseases in barley (*Hordeum vulgare*) production in Eastern Canada. In addition to reducing grain yields, the fungus produces a toxin (deoxynivalenol or DON) which can affect the health of livestock. The objective of this study was to determine the impact of different tillage systems on DON content in barley. The tillage systems were: T1: Conventional (fall moldboard plowing and spring harrowing – 2 passes with a cultivator), T2: Chisel (fall) and spring harrowing (2 passes with a cultivator), T3: Chisel (fall) and spring harrowing (1 pass with cultivator), T4: No tillage (fall) and spring harrowing (1 pass with a rotative harrow), T5: No tillage (fall) and spring harrowing (1 pass with a cultivator) and T6: No-till (no tillage the previous fall and no harrowing in spring). Those tillage systems were initiated in 1990 and since then, barley was grown without rotation. The DON content of grain has been determined since 2003. In general, the highest DON contents were obtained with direct seeding (T6) while the lowest DON contents were obtained with plowing (T1) or chiseling (T2 and T3). Because the fungus that causes FHB survives on residue left on the soil, and according to the results of this trial, tillage practices that bury cereal residue could be used to reduce deoxynivalenol (DON) content in barley.

2012 UNIFORM FUNGICIDE PERFORMANCE TRIALS FOR THE SUPPRESSION OF FUSARIUM HEAD BLIGHT IN SOUTH DAKOTA

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ABSTRACT

Fusarium head blight (FHB – scab) has been a serious concern for wheat and barley producers in South Dakota for over twenty years. The objective of this study was to continue to evaluate the effects of various fungicides and fungicide combinations along with different application timings for the suppression of Fusarium head blight and other wheat diseases. Two hard red spring wheat cultivars, 'Brick' and 'Oklee', were planted at three South Dakota locations (Groton, South Shore/Watertown and Volga). 'Wesley' winter wheat study sites were also established at South Shore/Watertown and Volga. Studies at Groton and South Shore were conducted under ambient conditions. The Volga site was under ambient conditions until anthesis, after which mist irrigation was applied. Trial treatments from the Uniform Fungicide Trial treatments list for the suppression of FHB included an untreated check and the following fungicides: Applied at Feekes growth stage 10.51: Caramba® (14 fl oz/A), Prosaro® (6.5 fl oz/A) and Onset® (4 fl oz/A); Applied at Feekes growth stage 9: Headline SC® (6 fl oz/A) followed by Caramba (14 fl oz/A) at Feekes growth stage 10.51; Applied at Feekes growth stage 9: Headline SC (6 fl oz/A) followed by Prosaro (6.5 fl oz/A) at Feekes growth stage 10.51; Applied at Feekes growth stage 9: Headline SC (6 fl oz/A) followed by Onset (4 fl oz/A) at Feekes growth stage 10.51; Applied at Feekes growth stage 10.51: Onset (4 fl oz/A) plus Caramba (10 fl oz/A) together; Applied at 3-7 days after Feekes growth stage 10.51: Caramba (14 fl oz/A) and Prosaro (6.5 fl oz/A). All treatments except the Headline SC 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. Winter wheat locations were planted in a randomized complete block design with four replications. Spring wheat plots at the Volga location were inoculated by spreading *Fusarium graminearum* (isolate Fg4) inoculated corn (*Zea mays*) grain throughout the field and providing overhead mist irrigation applied from 5:00 pm until 10:00 pm each day for 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. No significant treatments were found at the Groton location because ambient conditions were too hot and dry for FHB to develop. At the South Shore/Watertown location for spring wheat, the resistant variety, 'Brick', did not have any FHB or DON present for any of the treatments whereas in the susceptible variety "Oklee", visual scab ratings were not found but one treatment was positive for DON, namely the Onset + Caramba treatment sprayed at Feekes 10.51. At the Volga location for spring wheat, no significant treatments for FHB Incidence, Severity and Field Index for the resistant variety "Brick" were found, but all treatments were significant in reducing FDK levels. On the susceptible variety "Oklee", three treatments showed significance for FHB Incidence: Caramba applied at 3-7 days after Feekes 10.51, Headline applied at Feekes 9 + Prosaro applied at Feekes 10.51 and Prosaro applied at 3-7 days after Feekes 10.51. No treatments caused a significant reduction in FDK or DON on Oklee at Volga.

Overall, the hot and dry weather was not conducive for FHB development this year in the state of South Dakota. Even at the Volga site where artificial inoculation and misting were used, no significant amount of DON was produced.

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CHARACTERIZATION OF DIFFERENTIAL SPIKE COLONIZATION AND DEOXYNIVALENOL ACCUMULATION IN SUSCEPTIBLE AND RESISTANT WHEAT CULTIVARS

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ABSTRACT

Fusarium head blight (FHB) development and deoxynivalenol (DON) contamination of wheat are difficult to control. The two major means of combating FHB are the application of fungicides and the use of resistant cultivars in an effort to reduce visual symptoms (spike necrosis) and associated grain yield and quality losses. However these approaches do not always provide adequate reduction of DON levels. Although different types of resistance to FHB are reported and commonly used in FHB research, these have not been completely characterized. There is little research-based information on how different types of resistance are interrelated and how weather conditions affect their manifestation. Type II resistance (fungus spread) does not always parallel Type III resistance (mycotoxin accumulation). Under certain weather conditions, cultivars with high levels of Type II resistance may have DON accumulation comparable to that of cultivars with lower levels of Type II resistance. The goal of this study was to better characterize resistance to FHB in wheat through a better understanding of infection, colonization, and DON accumulation in symptomatic and asymptomatic spikes of resistant and susceptible cultivars. Two soft red winter wheat cultivars, one moderately resistant (Truman) and the other susceptible (Cooper) to FHB (based on visual symptoms), were grown under greenhouse conditions. The experimental design was a randomized complete block with a split-split-plot arrangement of temperature (whole plot), cultivar (sub-plot), and moisture durations (sub-sub plot). Individual plants reaching anthesis (Feekes GS 10.5.1) were point-inoculated in the central floret of the central spikelet with a highly aggressive isolate of *F. graminearum*. After inoculation, separate groups of plants were incubated in growth chambers at one of three temperatures (15, 20 and 25^{o}C), at high relative humidity (>90%). A subset of spikes was sampled at three-day intervals from each growth chamber, for a total of 21 days. For each spike, spikelets, rachises and grain were sampled at regular intervals above and below the point of inoculation and assayed for fungal growth and DON. Spread within the spike was quantified by measuring the distance of mycelial growth and necrosis along the rachis from the point of inoculation. At 15^{o}C, fungal growth inside the rachis, both above or below the point of inoculation, was observed in the susceptible cultivar after 6 to 9 days of high moisture and after 9 to 12 days in the resistant cultivar. When the cultivars were compared at higher temperatures (20 and 25^{o}C), fungal growth in the rachis was observed after 3 days in the susceptible cultivar and after 6 days in the resistant cultivar. The mean number of bleached spikelets above or below the point of inoculation ranged from 0 to 2 at 15^{o}C and from 0 to 7 at 20 and 25^{o}C, depending on the moisture duration. At 15^{o}C, it took less time (15 to 18 days) for two spikelets above and/or below the inoculated spikelet to become bleached on the susceptible than the resistant cultivar (21 days). When compared at 20^{o}C, two bleached spikelets were observed at 6 days after inoculation (dai) on the susceptible cultivar compared to 9 dai on the resistant cultivar. However, when compared at 25^{o}C, no visual differences in the number of bleached spikelets were observed between Cooper and Truman, and both cultivars had two bleached spikelet above or below the point of inoculation at 12 dai. Averaged across all moisture durations, measuring from the point of inoculation, mean necrotic damage of the rachis at the low temperature (15^{o}C) ranged from

0 to 10.71 mm for Cooper and from 0 to 3.39 mm for Truman; at the mild temperature (20°C), mean necrotic damage ranged from 0 to 14.94 mm and 0 to 33.13 mm for Cooper and Truman, respectively; and at the high temperature (25°C) from 0 to 34.56 mm and 0 to 23.67 mm for Cooper and Truman, respectively. DON results were not available at the time this report was being prepared.

INTEGRATED MANAGEMENT STRATEGIES FOR FUSARIUM HEAD BLIGHT OF SOFT RED WINTER WHEAT IN MISSOURI: SUMMARIZATION OF SIX YEARS OF TRIAL DATA

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OBJECTIVE

To evaluate the importance of crop sequence, variety selection and fungicide application as components of an integrated management program for Fusarium head blight (FHB) of soft red winter wheat in Missouri.

INTRODUCTION

The severity of FHB or scab epidemics in the United States has caused enormous yield and quality losses in both wheat and barley over the last decade or more. The development of this disease is dependent on the genetics of the host, favorable environmental conditions, the prevalence of the causal fungus and the survival and spread of the causal fungus. Control of this disease has been difficult because of the complex nature of the host-pathogen interaction. Management of FHB and the associated mycotoxin DON have not been achieved by any single control measure. An integrated approach is critical to attaining the best possible management of FHB and DON in any given environment.

As a result of a workshop sponsored by the Chemical, Biological and Cultural Control Research Area of the U.S. Wheat & Barley Scan Initiative in 2006, a protocol for a multi-state project focusing on integrated management strategies for FHB was developed. The research portion of the project has been multi-state trials evaluating crop sequence, variety selection and fungicide application as an integrated management program for FHB.

The University of Missouri has participated in the multi-state integrated management project for the past six growing seasons. Results from the six years are summarized in this poster abstract.

MATERIALS AND METHODS

During the fall of 2006 two adjacent fields at the University of Missouri Bradford Research and Extension Center just east of Columbia, MO, were identified for this study. The fields had been in a corn/soybean rotation for at least five years prior to the initiation of the study and were separated by a small drainage ditch. The wheat trials were planted into standing corn residue or soybean residue on the same day. The remainder of each field was planted into the normal rotation crop of corn or soybean. In subsequent years, the wheat trials were shifted to other areas of the same fields with the remainder of the fields planted to the normal rotational crop.

Five soft red winter wheat varieties with similar heading times and varying reactions to FHB were selected for the trial. The five varieties included the public varieties Bess (tolerant) and Roane (moderately tolerant) which are widely grown in Missouri, the Agri-Pro variety Elkhart (susceptible) and the Pioneer varieties 25R47 (moderately susceptible) and 25R54 (moderately tolerant).

In the fall of 2006 the trials were planted no-tillage into either soybean residue or standing corn residue on the same day. Individual plots were 7 rows (~7.5” row spacings) by 30’ in length. Each trial was set up as a split plot trial with fungicide application as the main plot and variety as the sub-plot. There were six replicates in each trial. Sub-plots were separated by buffer plots. The foliar fungicide Prosaro® (6.5 fl oz/A) was applied at Feekes growth stage 10.5.1. A non-ionic surfactant was added to the fungicide at the rate of 0.125% v/v, and application was made using a CO_2 pressurized backpack sprayer with TwinJet XR8002 nozzles mounted at an angle (30 and 60 degrees) forward and backward.

Plots were evaluated for incidence and severity of FHB, yield was taken, grain samples were submitted to North Dakota State University for DON analysis and grain samples were rated for percent of Fusarium damaged kernels (FDK). Analysis of variance was used to determine the effects of variety, fungicide and their interactions on yield, DON levels and FHB index (average of 100 wheat heads per plot) and percent FDK for each residue type.

The trial was repeated following the same protocol during the next five growing seasons.

RESULTS

Weather conditions during the 2007 growing season were not conducive for the development of FHB at the Columbia, MO location. Conditions as the wheat crop was flowering were too dry for infection to occur and for disease to develop. However, the following five seasons have been more conducive for the development of FHB. In 2008, 2009 and 2010 weather conditions were unusually wet and cool as the wheat crop flowered and after flowering so both scab and DON levels were high. The 2011 and 2012 seasons were wet during flowering so scab developed but were hot and dry during grain fill so FHB index and DON levels were lower than in the previous three years.

The results from the six years of this trial demonstrate the importance of crop sequence, variety selection and fungicide application in reducing FHB and DON levels in soft red winter wheat grown in Missouri. Planting wheat after soybean rather than corn showed a reduction in both FHB and DON even in years which were not particularly favorable for the development of FHB. Crop sequence and variety selection appear to be valuable preventative measures for reducing FHB and DON levels. The application of the fungicide Prosaro at FGS 10.5.1 tended to reduce FHB levels and increase yields for most of the varieties on both crop sequences with effects being more pronounced on susceptible and moderately tolerant varieties. The data from the six years of this trial indicate that an integrated management approach employing crop sequence and variety selection as pre-plant preventative management measures and fungicide application during the growing season if weather conditions at flowering warrant application may be beneficial in reducing FHB, reducing DON levels and increasing yield for soft red winter wheat grown in Missouri.

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UNIFORM FHB INTEGRATED MANAGEMENT TRIALS: A SUMMARY FROM 2012

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OBJECTIVE

To evaluate the integrated effects of fungicide and genetic resistance on FHB and DON in small grain crops in different environments.

INTRODUCTION

From 2009 to 2011, coordinated, uniform trials were conducted in multiple states to evaluate the effects of grain class, crop rotation, cultivar resistance, and fungicide application on management of FHB and DON. Results from over 40 wheat trials demonstrated using fungicide or moderate resistance alone resulted in approximately 53 and 54% control in FHB index, respectively; and 39 and 51% control in DON, respectively (Willeyard et al). Combining moderate resistance (in hexaploid wheat) and fungicide resulted in 76 and 71% control of index and DON; furthermore, the efficacy of this integrated approach was stable across different environments and cropping systems. However, more research is required to evaluate these effects under higher disease pressure and in other small grain classes such as barley and durum wheat. In a given year of this coordinated effort, 20 to 54% of trials were eliminated from analysis due to little to no FHB and/or DON in the susceptible, untreated check, as low disease in the reference makes calculating the effects of treatment impossible. This report summarizes results from trials conducted during the 2012 season, including trials with the factor of artificial inoculum, which was hypothesized to increase the amount of "useable" data (that is, trials with significant disease in the check).

MATERIALS AND METHODS

Trials were established in fields following a host or non-host crop of *F. graminearum*. At least three commercial small grain cultivars, classified as susceptible (S), moderately susceptible (MS) or moderately resistant (MR), were planted in three to six replicate blocks in each trial. The standard experimental design was a randomized complete block, with a split-split-plot arrangement of cultivar (whole-plot), inoculation (sub-plot) and fungicide treatment (sub-sub-plot; UT, untreated and TR, treated). Some trials used fungicide as whole-plot and cultivar as sub-sub-plot; while others did not include inoculation as a factor. Fungicide (Prosaro®, 6.5 fl. oz/A + NIS) was applied at anthesis, using CO_2 powered sprayers, equipped with Twinjet XR8002 or paired XR8001 nozzles, mounted at a 30 or 60° angle, forward or backward. For trials with artificial inoculations, either *F. graminearum*-colonized corn kernels were spread on the soil surface of plots prior to anthesis or plots were spray-inoculated with a spore suspension of the fungus approximately 24 hours following fungicide treatments. FHB index (plot severity) was assessed during the dough stages of grain development. Milled grain samples were sent to a USWBSI-supported laboratory for toxin analysis. Proc GLIMMIX of SAS was used to evaluate the effects of fungicide, cultivar, (and inoculation, when appropriate) and their interactions on index and DON (assuming a significance level $\alpha = 0.05$). Percent control was calculated to compare the effect of cultivar resistance and fungicide treatment combinations (S_TR, MS_UT, MS_TR, MR_UT and MR_TR) on index and DON to the susceptible, untreated check (S_UT).

RESULTS AND DISCUSSION

At the time of this summary, data were collected from 22 trials, conducted in 7 states (IL, IN, MO, ND, NY, OH and SD) (Table 1). These included 9 soft red winter wheat (SRWW), 4 hard red winter wheat (HRWW), 4 six-row barley, 3 hard red spring wheat (HRSW) and 2 two-row barley trials. FHB index and DON accumulation varied among locations and grain classes (Table 1). Overall, mean FHB was 0% in many locations (environments 1, 2, 3, 7, 8, 9, 10 and 11), and as a result, DON accumulation was also low or samples were simply not sent for toxin analysis (Table 1). Only environments with > 5% mean index (4, 5, 6, 12, 13, 21 and 22) and/or >1 ppm mean DON (4, 5 and 6) in the susceptible, untreated check were included in this analysis (Table 1). Means for cultivar resistance class x fungicide treatment combinations and percent control of index and DON, relative to the untreated susceptible check (S_UT), are found in Table 2.

Illinois. Six soft red winter wheat cultivars were planted into host residues in two trials that included artificial inoculation as a factor. Despite the presence of FHB in both trials, DON levels were well below 1 ppm perhaps due to rapid grain maturation and relatively early harvest in 2012. **Monmouth (ENV 21).** Index, DON and yield observations ranged from 0 to 100%; 0 to 0.2 ppm and 75.7 to 106.7 bu/A, respectively. Neither cultivar, fungicide treatment (Table 3) nor inoculation (data not shown) had significant effects on index. In this environment the MS_TR combination resulted in the greatest control in index (97%), followed by MS_UT and MR_TR (both approximately 70%, Table 2). **Urbana (ENV 22).** Index, DON and yield observations ranged from 0 to 18%; 0 to 0.4 ppm and 52.8 to 94.4 bu/A, respectively. Both cultivar and fungicide had significant effects on index and DON (Table 3). Inoculation did not have a significant effect on either response (data not shown). All management combinations resulted in <3% FHB index and reduced index by over 60% compared to the S_UT check (Table 2)

Missouri. Five soft red winter wheat cultivars were planted into host and non-host crop residues near Columbia, MO. These two trials relied on ambient inoculum. Overall, mean FHB index, DON and yield were greater in the non-host (soybean) environment compared to that of the trial planted following corn, despite the same planting and treatment dates. **Host residues (ENV 4).** Index, DON and yield observations ranged from 6.7 to 32%; 0 to 4 ppm and 45.7 to 90.0 bu/A, respectively. Both cultivar and fungicide treatment had significant effects on index and DON (Table 3). Generally, index and DON decreased with improved resistance and fungicide treatment application, however, S_TR showed improved DON control compared to MS_UT (Table 2). The MR_TR combination resulted in the greatest control in index and DON (57 and 89%, respectively) compared to the S_UT check. **Non-host residues (ENV 5).** Index, DON and yield observations ranged from 7.3 to 39.1%; 0 to 12.5 ppm and 52.2 to 95.5 bu/A, respectively. The cultivar x fungicide interaction had significant effects on DON only (Table 3). Similar to the host residue environment, S_TR showed improved DON control compared to MS_UT and MR_TR had the greatest DON control (89%, Table 2). Both cultivar and fungicide treatment had significant effects on index (Table 3). Mean index decreased with improved resistance level and treatment. MR_TR resulted in the greatest control of index (66%, Table 2).

North Dakota **(ENV 6).** Six hard red winter wheat cultivars were planted into non-host residue near Carrington, ND. This trial was inoculated with colonized corn spawn followed by supplemental misting. Index and DON observations ranged from 0.05 to 62% and 2.1 to 14.9 ppm, respectively. Yield data were not available for this environment.

Cultivar and fungicide factors each had significant effects on index and DON (Table 3). Within each resistance class, fungicide treatment increased control of both index and DON, with MR_TR resulting in approximately 95 and 55% control of index and DON, respectively (Table 2).

South Dakota. Three trials, with three small grain cultivars each, were planted near Volga, SD. **HRSW (ENV 12).** This trial was established in non-host residue and was not artificially inoculated. Index, DON and yield observations ranged from 0 to 21.9%; 0 to 0.8 ppm and 34.9 to 55 bu/A, respectively. Only cultivar had significant effects on index (Table 3) and only the MR cultivar had significantly less index than that of S or MS cultivars (data not shown). The MR_TR combination had the greatest control of index (59%) compared to the S_UT. **6-Row Barley (ENV 13).** This trial was also established in non-host residue and was not artificially inoculated. An MS cultivar was not included in this trial. Index, DON and yield observations ranged from 8.6 to 17.9%; 0 to 1.2 ppm and 32 to 69.2 bu/A, respectively. Neither cultivar nor treatment had significant effects on index in this trial (Table 3). In general, the MR cultivar only provided between 4-5% control of index compared to the S_UT (Table 2). **HRWW (ENV 14).** This trial was established in host residue and artificial inoculation with colonized corn spawn was included as a third factor. Index, DON and yield observations ranged from 0 to 50%; 0 to 1.1 ppm and 36.2 to 61.6 bu/A, respectively. While the S_UT had index <5% and DON <1 ppm, the overall trial means exceeded these values, which is why this trial was included in the analysis. Neither cultivar nor treatment had significant effects on index in this trial (Table 3). Inoculation also did not have a significant effect on index ($F = 0.16$, $P = 0.69$; data not shown). Interestingly, the S cultivar had the lowest levels of mean index and DON out of all resistance classes. This may be explained, in part, by differences in flowering date among the cultivars. Reportedly, rain events occurred during flowering of the MS and MR cultivars, but the S cultivar may have "escaped", reaching peak flowering during a dry period.

CONCLUSIONS

In most trials, the use of an MR cultivar reduced both index and DON, relative to the untreated, susceptible check. The effect of fungicide was slightly more variable across trials, potentially due to interactions between fungicide efficacy and environmental conditions. In general, fungicide application increased percent control of index and DON within each resistance category. However, there were some exceptions to this, observed within the MS cultivar this year. Most frequently, the combination of MR_TR resulted in the greatest level of control across trials. The degree of this control was dependent on each environment's unique cultivars and cropping system. Several trials incorporated artificial inoculations this year in an effort to provide more useable data (>5% index and >1 ppm DON in the S_UT); however, unless supplemental misting accompanied inoculations (as done in corn spawn-inoculated trials), the dry conditions prevalent in many small grain growing regions this year likely thwarted potential infections and disease development.

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Table 1. Study descriptions, trial-wide mean index, DON and yield (across all treatments and reps) and mean index and DON for the susceptible, untreated (S_UT) check from 22 coordinated integrated management trials (ENV, environments) in 2012.

					Trial-wide means			S_UT Check	
ENV	LOCATION	CLASS	PREVIOUS CROP	INOC?	Index %	DON ppm	Yield bu/A	Index %	DON ppm
1	IN	SRWW	host	Y	0.00	.	62.40	0.00	.
2	Aurora, NY	SRWW	host	Y	0.00	0.06	93.08	0.00	0.06
3	Aurora, NY	SRWW	non-host	Y	0.00	0.02	125.83	0.00	0.04
4	Bradford, MO	SRWW	host	N	13.62	1.25	66.98	24.27	3.07
5	Bradford, MO	SRWW	non-host	N	16.71	2.85	75.05	32.40	9.45
6	Carrington, ND	HRWW	non-host	Y	8.61	7.17	.	23.85	10.00
7	Forman, ND	HRWW	host	N	0.00	0.00	75.72	0.00	0.00
8	Forman, ND	HRSW	non-host	N	0.00	0.00	63.89	0.00	0.00
9	Prosper, ND	HRWW	host	N	0.00	0.00	79.06	0.00	0.00
10	Finley, ND	HRSW	non-host	N	0.00	0.00	71.71	0.00	0.00
11	Finley, ND	6rowBARLEY	non-host	N	0.00	0.05	67.56	0.00	0.05
12	Volga, SD	HRSW	non-host	N	11.48	0.12	46.72	17.75	0.12
13	Volga, SD	6rowBARLEY	non-host	N	12.87	0.51	44.95	12.96	0.51
14	Volga, SD	HRWW	host	Y	6.40	0.09	50.64	3.31	0.09
15	Wooster, OH	SRWW	non-host	Y	2.34	0.11	93.45	4.24	0.21
16	Fargo, ND	2rowBARLEY	host	N	0.389	.	41.87	0.54	.
17	Fargo, ND	2rowBARLEY	non-host	N	0.184	.	17.95	0.18	.
18	Fargo, ND	6rowBARLEY	non-host	N	0.229	.	20.58	0.39	.
19	Fargo, ND	6rowBARLEY	host	N	0.159	.	49.32	0.24	.
20	Dixon Springs, IL	SRWW	host	Y	4.64	0.04	51.41	4.06	0.15
21	Monmouth, IL	SRWW	host	Y	17	0.02	88.46	39.11	0.08
22	Urbana, IL	SRWW	host	Y	11.96	0.06	74.81	34.48	0.18

Table 2. Mean FHB index and DON and percent control for each management combination, relative to the untreated, susceptible check (from trials (ENV) with >5% index and/or >1 ppm DON in the check).

		Resistance x Treatment Combination*						% Control Compared to S_UT				
Response	**ENV**	**S_UT**	**S_TR**	**MS_UT**	**MS_TR**	**MR_UT**	**MR_TR**	**S_TR**	**MS_UT**	**MS_TR**	**MR_UT**	**MR_TR**
Index (%)	4	24.27	19.47	14.32	12.65	11.33	10.49	19.79	41.01	47.88	53.33	56.76
	5	32.40	26.78	19.52	16.70	12.80	11.08	17.34	39.76	48.46	60.49	65.79
	6	23.85	5.54	9.14	2.73	9.40	1.01	76.78	61.68	88.57	60.59	95.75
	12	17.75	11.13	11.86	12.48	8.40	7.28	37.28	33.16	29.68	52.68	59.00
	13	12.96	13.29	.	.	12.35	12.40	-2.51	.	.	4.69	4.35
	14	3.31	3.50	5.83	11.25	10.42	4.08	-5.74	-76.23	-239.88	-214.70	-23.36
	21	39.11	27.19	11.25	1.25	19.35	11.95	30.48	71.23	96.80	50.53	69.44
	22	7.19	2.13	1.31	1.13	2.61	0.00	70.45	81.75	84.35	63.71	100.00
DON (ppm)	4	3.07	1.70	2.60	1.62	0.82	0.34	44.63	15.31	47.34	73.22	88.78
	5	9.45	4.43	5.10	3.27	1.32	0.49	53.09	46.03	65.43	86.07	94.78
	6	10.00	10.05	7.59	5.73	5.09	4.55	-0.50	24.13	42.75	49.13	54.50

*Resistance x treatment combinations included: susceptible, untreated check (S_UT); susceptible, treated (S_TR); moderately susceptible, untreated (MS_UT); moderately susceptible, treated (MS_TR); moderately resistant, untreated (MR_UT); moderately resistant, treated (MR_TR).

Table 3. Effects of cultivar, fungicide and their interactions on FHB index and DON for those coordinated management trials with greater than 5% index and/or 1 ppm DON in the check.

		Cultivar Resistance		Fungicide Treatment		Cultivar x Treatment Interaction	
Response	**ENV**	***F Statistic***	***P-value***	***F Statistic***	***P-value***	***F Statistic***	***P-value***
Index (%)	4	77.31	<0.01	6.90	0.01	2.54	0.09
	5	52.52	<0.01	4.91	0.03	0.64	0.53
	6	4.37	0.02	14.33	<0.01	1.60	0.21
	12	6.50	0.02	3.62	0.08	3.06	0.08
	13	0.87	0.36	0.05	0.82	0.03	0.86
	14	0.63	0.54	0.00	0.95	0.76	0.48
	21	3.99	0.10	3.08	0.08	0.08	0.93
	22	6.25	<0.01	9.07	<0.01	1.96	0.15
DON (ppm)	4	61.41	<0.01	31.37	<0.01	3.01	0.06
	5	60.24	<0.01	25.58	<0.01	6.42	<0.01
	6	19.22	<0.01	0.49	0.53	0.66	0.52