SESSION 5:

FHB MANAGEMENT

EFFECTS OF PRE- AND POST-ANTHESIS MOISTURE PATTERNS ON IND/DON RELATIONSHIPS AND FHB AND DON RISK PREDICTION

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ABSTRACT

The effects of various moisture patterns on relationships between Fusarium head blight (FHB) and deoxynivalenol (DON) and the risk of these responses exceeding critical thresholds were evaluated with a set of field and controlled environment experiments conducted in Wooster, Ohio. Moisture is critical for infection, colonization, FHB development, and grain contamination with DON. It remained unclear, however, how the distribution of moisture during the time windows pre- and post-anthesis affect these responses and relationships between them. Field experiments were conducted to quantify the effects of pre-anthesis rainfall patterns, and mist chamber experiments to quantify the effects of post-anthesis mist patterns, on FHB, DON, and fungal biomass (FBM). For both sets of experiments, four moisture (rainfall or mist) treatments, one continuous (mist or rain every day, but not all day) and three intermittent, were applied during the 7-8 days before or after anthesis, along with an untreated check. Intermittent treatments received similar duration (h) and amounts of moisture, but the alternation between wet and dry periods during the 7-8-day window varied among these treatments. FHB index (IND) was rated, and a grain sample from each treatment was analyzed for DON. Linear mixed model (LMM) covariance analyses were performed to model the IND/logDON relationship, as influenced by moisture treatments. In all cases, there was a significant positive linear relationship between IND and DON. Moisture treatment did not affect the slope of the IND/DON regression line, but the intercepts varied among treatments. Both under field and greenhouse conditions (pre- and post-anthesis), one particular intermittent moisture treatment (wet days at the beginning and end of the 8-day window, separated by dry days) consistently resulted in comparable or significantly higher logDON than the continuous moisture treatment. Generalized LMMs were then fitted to the data and probabilities of IND > 10% and DON > 2, 5 and 10 ppm were estimated. Nearly all pre-anthesis rainfall and post-anthesis mist treatments had similar probabilities of IND > 10%, which were significantly higher than the untreated check. Results from the controlled-environment (post-anthesis) studies showed that the moisture treatment with two days of mist at the beginning and end of the 8-day window had as high or higher probability of DON exceeding 2, 5, or 10 ppm as the continuous moisture control.

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EFFECTS OF LOCAL CORN DEBRIS MANAGEMENT ON FHB AND DON LEVELS IN SEVENTEEN U.S. WHEAT ENVIRONMENTS IN 2011 - 2013

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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. The goal of this 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 three years, 2011, 2012, and 2013, from winter wheat in three states (IL, NE, and NY) and over two years, 2011 and 2012, from winter wheat in three states (KY, MI, and MO) and from 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.

In 2013, at soft dough stage, FHB index exceeded 25% in IL but was less than 5% in NE and NY, yet DON levels exceeded 2 ppm in all three locations. Neither FHB Index nor DON differed significantly by tillage treatment in IL or NE. Plowing did not result in reduction of infection incidence of mature heads in any location. Plowing of corn debris resulted in significant reductions in FHB and DON in NY.

There is a strong trend in three 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, and this is especially true in years with severe epidemics. Yet, where economically and logistically feasible, avoiding cereal residues within wheat fields, through appropriate rotational sequence, will sometimes result in modest reductions in DON, especially when weather conditions are only moderately favorable for epidemics. Therefore, cultural practices that avoid corn and small grains debris within wheat and barley fields still have a valuable though incremental role to play in the integrated management of FHB and DON.

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LOCAL CORN DEBRIS MANAGEMENT: WHAT DOES IT CONTRIBUTE TO HEAD BLIGHT AND MYCOTOXIN REDUCTION?

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ABSTRACT

Wheat or barley crops planted directly into cereal debris (source of *Fusarium graminearum* spores) are at increased risk for head blight and mycotoxins, but atmospheric inoculum from spores released over a wider geographic region presents an even greater risk for local cereal crops. Cultural practices based on avoidance of cereal residues or practices that promote residue decomposition and decrease *Fusarium* survival could reduce atmospheric spore levels significantly if implemented over a wide production region. However, planting of wheat or barley following a non-cereal crop is not feasible for logistic reasons for many producers. Other producers need to weigh the disease and toxin suppression benefits of such cultural practices against the economic costs of those measures. Probably the worst-case scenario for inoculum exposure and Fusarium head blight risk is the no-till planting of a susceptible wheat or barley cultivar into overwintered corn stubble. A three year project covering 17 U.S. wheat environments was conducted with moldboard plowing of corn debris used as an experimental proxy for planting after a non-cereal crop to compare directly with wheat planted no-till into corn debris in commercial-scale wheat strips, and thereby produce some realistic estimates of the 'DON reduction' effect of debris management in individual fields. [See FHB Management Poster # 49 by Bergstrom, Cummings, Waxman, Bradley, Wegulo, Hazelrigg, Hershman, Nagelkirk, and Sweets.] Findings from this research along with other observations and results in the literature will be discussed with a goal to define a range of values that could be attached to cultural practices within an integrated FHB management program.

EFFECT OF CULTIVAR AND FUNGICIDE ON *FUSARIUM* MYCOTOXINS IN WHEAT STRAW

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ABSTRACT

Fusarium head blight is known for yield reduction and mycotoxin accumulation in wheat grains that are detrimental to both human and animal health. Fungicides and cultivars have been shown to have varying effects on toxin accumulation in grains, but little is known about their effects on mycotoxin accumulation in straw tissue. Wheat straw is commonly used as bedding material for livestock and can accumulate toxins in much higher levels than the associated grains from the same crop. Non-ruminants are especially affected by the toxins such as swine which can eat 2 to 4 kg of wheat straw bedding per day. Research trials conducted in 2013 in Illinois determined the levels of mycotoxins present in wheat straw samples (stems only) and if fungicides or cultivar had an effect on mycotoxin levels. Stem samples were collected immediately after harvest and were sent to the University of Minnesota mycotoxin testing laboratory.

Fungicide trials were conducted at 4 location in Illinois in 2011, 2012, and 2013 (Brownstown, Dixon Springs, Monmouth, and Urbana) to determine the effects of Priaxor® [in 2013] and Headline® [in 2011 and 2012] (fungicides containing 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. Priaxor or Headline was applied at Feekes growth stage (FGS) 9, while all other fungicides were applied at FGS 10.5.1. Mycotoxin concentration ranges for DON, 3ADON, 15ADON, NIV, and ZEA in wheat stems at these locations across all three years were 0.19-154.5 ppm, 0.0-10.1 ppm, 0.0-29.8 ppm, 0.0-5.2 ppm, and 0.0-2.5 ppm, respectively. When averaged over all location in 2011 and 2013, none of the fungicides decreased mycotoxin levels as compared to the non-treated control. However, pyraclostrobin-containing fungicides significantly ($P \leq 0.10$) increased DON, 15ADON, and 3ADON concentrations in wheat stems as compared to the non-treated control in 2011 and 2013.

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. The Monmouth location was omitted for 2013. Ranges of DON, 3ADON, 15ADON, NIV, and ZEA concentrations in wheat stems from these trials from 2011 to 2013 were 0-45.3 ppm, 0-3.3 ppm, 0-15.7 ppm, 0-2.3 ppm, and 0-5.5 ppm, respectively. When averaged over all trials from 2011 to 2013, the susceptible cultivar (Pioneer 25R47) had significantly ($P \leq 0.10$) greater DON levels compared to the moderately resistant cultivar (BW5228). For the trials conducted in 2011 and 2013, 15ADON present in stem tissue of the untreated, susceptible cultivar was significantly higher than any of the other treatments. 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 through 2013. Ranges of DON, 3ADON, 15ADON, NIV, and ZEA were 0.08-135.2 ppm, 0-20.0 ppm, 0-25.5 ppm, 0-1.9 ppm, and 0-0.98 ppm, respectively. Overall, significantly higher 3ADON was found in wheat stems in 2011 and 2013 across all cultivars, while 2012 recorded significantly higher NIV. In 2011 and 2013, significant differences were also found in the levels of DON, 3ADON, and 15ADON in stems among cultivars. In 2012, no significant differences in stem mycotoxin levels were observed among cultivars.

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UNIFORM TESTS OF BIOLOGICAL CONTROL AGENTS FOR MANAGEMENT OF FHB AND DON, 2013

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ABSTRACT

Fusarium Head Blight (FHB) caused by *Fusarium graminearium* (*Gibberella zeae*) is an economically important disease observed in wheat, barley and certain corn varieties. FHB can be controlled or reduced through the use of chemical and / or biological control agents (BCAs). Uniform biocontrol field plot trials were conducted at sites in New York, Nebraska, and South Dakota to analyze the efficacy of the commercially available *Bacillus* biocontrol product Taegro® with / without selected amendments. Prosaro® or Tebuconazole was sprayed at Feekes 10.51, while Taegro with / without Canola oil and nitrogen were applied late after the application of Prosaro or Tebuconazole. Biological control activity of Taegro was compared with an untreated control and a standard treatment of the fungicide Tebuconazole or Prosaro, with the use of additional amendments like Canola oil and a nitrogen amendment. Assessment of efficacy of the Taegro BCA was done by analyzing the wheat heads for FHB disease incidence, severity, index, DON, FDK, yield and grain test weight. In New York, severity of powdery mildew and fungal leaf blotches on flag leaves was also assayed.

For the one field site in Nebraska that provided data, the addition of Taegro with or without additional amendments did not result in any significant treatment effects compared to the fungicide alone.

In the Brookings, South Dakota field plot trial, no statistically significant (P=0.10) differences were observed for FHB disease incidence, severity, index, and grain test weight for any treatments in comparison to the untreated control. However, reduced FHB incidence, severity and index were observed for some treatments. Some treatments exhibited significant treatment differences for yield in comparison to the untreated control, particularly Taegro with Prosaro and the nutritional amendment to stimulate the BCA. The DON data for the South Dakota trial are not yet available as of November 2013.

In the New York field plot trial, all treatments resulted in significantly lower severity of powdery mildew and fungal leaf blotches on flag leaves than the non-treated control, with the exception of the late application of Taegro with canola oil and nitrogen. Overall, treatments that included Prosaro resulted in the best control of foliar diseases, and treatments including Tebuconazole resulted in better control of foliar diseases than any biocontrol alone treatments. FHB developed in all plots at moderately low levels, with significant differences among treatments for FHB incidence and FHB index. Prosaro application at flowering resulted in significant reductions in FHB incidence and index, but only resulted in modest reductions of FDK and DON which may be attributed to later infection after the fungicide applications. Though it resulted in significant reductions of FHB incidence and index, Tebuconazole application did not reduce FDK or DON. The combining of Prosaro or Tebuconazole with any of the biocontrols neither enhanced nor diminished the fungicide's ability to suppress FHB, FDK, or DON.

Taegro applications that were not combined with either fungicide resulted in no significant reduction of FDK or DON. Only treatments including Prosaro resulted in significantly lower FDK than the non-treated control. There were no statistically significant differences in DON or yield among any of the treatments. Only treatments including Prosaro and the treatment with Tebuconazole at flowering followed by Taegro resulted in higher test weights than the non-treated control.

Since Taegro is a commercially available *Bacillus* BCA product that is currently available to producers, further efforts to optimize its efficacy in the field using chemical amendments seem warranted. Some field sites and Taegro treatments in the 2013 uniform BCA trial indicated that Taegro in combination with fungicide can either reduce some measures of FHB and/or increase yield.

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PROGRESSION OF DON IN WHEAT INFECTED FROM 0 TO 13 DAYS AFTER MID-FLOWERING

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ABSTRACT

Previous research had indicated that physiological susceptibility of winter wheat to Fusarium head blight essentially ends between 7 and 10 days after mid-anthesis, but could vary according to both environment and host resistance genotype. The present study aimed to clearly establish when and how rapidly the window of wheat susceptibility to FHB infection closes. An inoculated, mist-irrigated field experiment was performed in Raleigh, NC. Timings were set up to explore the timeframe between 7 and 10 days after mid-anthesis. Plots of the susceptible cultivar P26R12 and the moderately resistant cultivar NC-Neuse, both soft red winter wheats, were inoculated at 0, 3, 5, 6, 7, 8, 9, 11, or 13 days after mid-anthesis (daa) with a suspension of 5 x 10^5 macroconidia/ml of *Fusarium graminearum*. A single inoculation-date treatment was applied to each plot. All cultivar inoculation-date treatments were replicated four times. Mist-irrigation was provided for 28 daa to ensure conditions were conducive for infection at all inoculation timings. From each plot, primary spikes were sampled at 14, 21, 28, 35, 42 days after inoculation (dai), and spikes were sampled at harvest ripeness in all plots, in order to assess the effect of infection timing on visual kernel damage, *Fusarium* infection of grain, and DON contamination**.** Growth stage at each inoculation date was determined by dissecting other sampled spikes, and temperature and rainfall were monitored using a local weather station.

For the 0- and 3-daa inoculations in both cultivars, DON was at extremely high levels in the 14- and 21-dai samples, tended to plateau in the subsequent 3 samples, and then declined as harvest approached. For inoculations at 5 daa and later, DON peaked on average at 35 daa (30-35 daa in the MR cultivar, 35-40 daa in the S cultivar), and declined in the subsequent 20 days.

For both cultivars, DON concentrations at harvest-ripeness showed a declining trend as inoculations became later after mid-anthesis, starting with the 5-daa inoculations. DON levels ≥2 ppm were obtained from the MR cultivar when inoculated at 0, 3, or 5 daa after mid-anthesis, and from the S cultivar when inoculated at those and also two later timings, 6 and 8 daa. Reinforcing earlier results, these findings indicate that the window of susceptibility to economically damaging scab epidemics may be longer in S cultivars than in MR cultivars. One implication is that cultivar susceptibility should be a factor in deciding how late after wheat flowering it will be cost-effective to apply a fungicide. In other words, a significant benefit is more likely to be seen from a late application to a susceptible cultivar than to a moderately resistant one.

EVALUATION OF INTEGRATED METHODS FOR MANAGING FHB AND DON IN WINTER WHEAT IN NEW YORK IN 2013

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OBJECTIVE

To evaluate the individual and interactive effects of moderately resistant cultivars and application of the fungicide Prosaro at initiation of flowering on wheat yield and the integrated management of Fusarium head blight (FHB) and deoxynivalenol (DON) under two cropping 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 2013, 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' (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 plots, both planted on October 10, 2012, 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 plot with four wheat cultivars as whole plots and inoculation or fungicide application treatments as subplots 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 6/1/13 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 an Almaco plot combine on 7/16/13. Grain moistures, plot yields, and test weights were recorded with the latter two adjusted for moisture at 13.5%. Analysis of DON content in grain was conducted in the USWBSI-supported mycotoxin laboratory of Dr. Dong. Means were calculated and subjected to Analysis of Variance. Fisher's protected LSD was calculated at P=0.05.

RESULTS AND DISCUSSION

The incidence of FHB over all plots in the two experiments ranged from 6 to 35%. The impact of supplemental inoculation with *F. graminearum* was determined by comparing the non-inoculated and inoculated treatments (combining non-sprayed and Prosaro treatments). Inoculation did not significantly affect yield, FHB index, or DON, regardless of treatment or variety in the corn stubble environment, but had a modest effect on FHB incidence for the treatment means in the soybean stubble environment. There were no significant differences in cultivar response to inoculation for FHB index between the two environments. FHB and DON in 2013 are attributed primarily to natural rather than supplemental inoculum.

Under moderately low disease pressure, significant differences were detected in yield potential among the varieties with Pioneer 25R46 consistently yielding highest and Truman yielding lowest. Yield for each cultivar was significantly higher following soybean than following corn. This may be attributable to decreased FHB as well increased nitrogen following soybean.

When results of all the cultivars were combined, the overall impact of the Prosaro applications in both environments was to significantly decrease FHB incidence, index, DON, and foliar diseases, and to significantly increase yield and test weight. Prosaro application significantly reduced FDK only in the corn stubble environment where the disease pressure was highest.

All measures of Fusarium head blight were higher in the presence of corn stubble suggesting a dramatic within-plot increase in available spore inoculum from corn debris. The most striking observation was the average 7-8 fold increase in DON contamination levels in grain where wheat followed no-till after corn as compared to soybean. On the other hand, artificial inoculation at flowering with conidial suspensions had almost no significant effect on FHB parameters following either corn or soybean. The fairly late development of FHB symptoms is consistent with infections occurring during moist conditions after peak flowering and for which spores from within-plot corn debris may have contributed a greater portion than sprayed conidia or regional atmospheric inoculum. Otsego, regarded initially as moderately resistant to FHB, was significantly more susceptible than the other cultivars, thus should be designated as no better than moderately susceptible. Pioneer 25R46 showed reduced levels of FHB and DON and should probably be designated as moderately resistant along with the moderately resistant check cultivar Truman.

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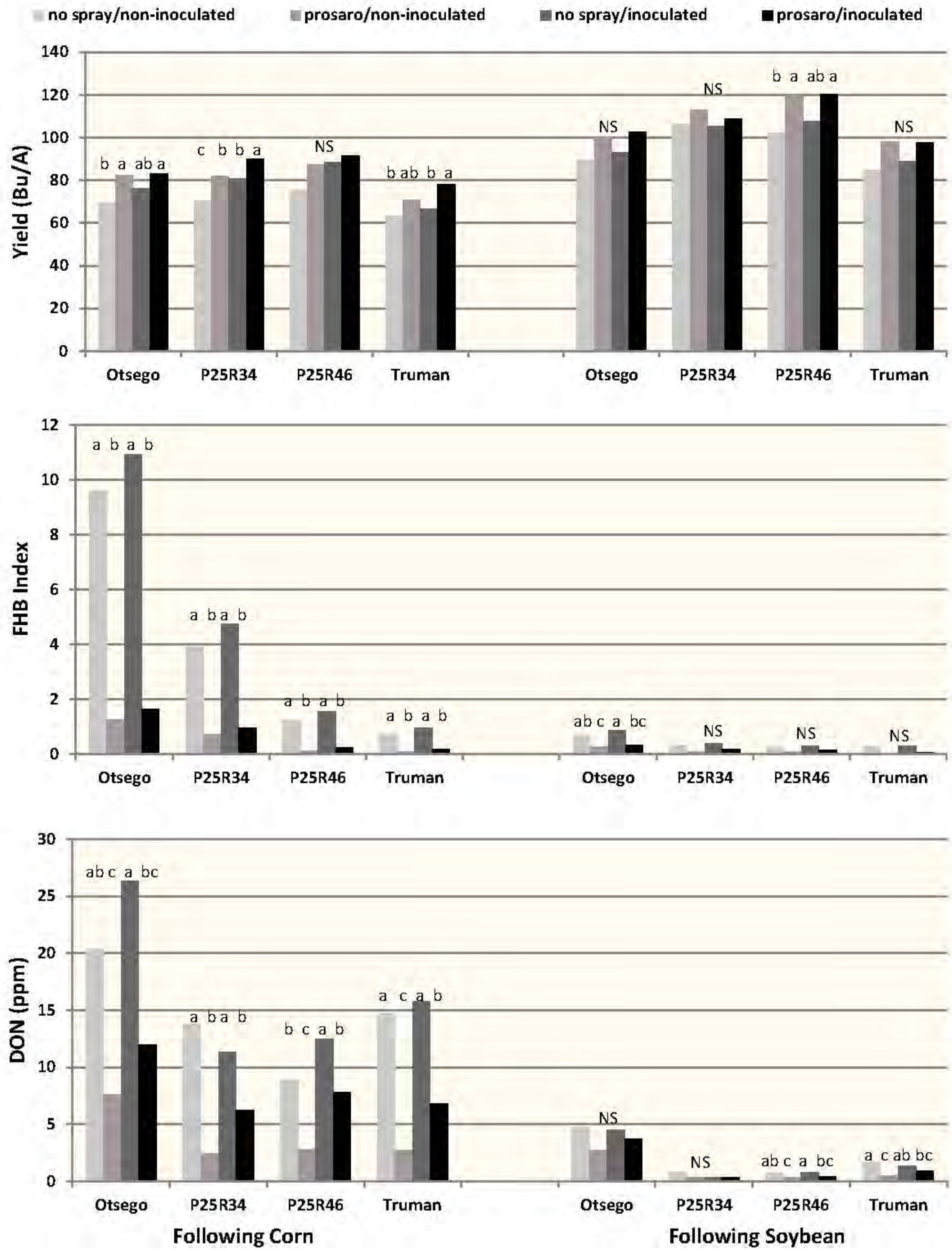

Figure 1. Effect of Prosaro® fungicide application and *F. graminearum* inoculation on yield, FHB index and DON contamination of four winter wheat cultivars in two different environments in Aurora, NY.

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

	Adjusted grain yield (bu/A) at 13.5% moisture		
Treatment:	After corn	After soybean	Average
Non-sprayed, non-inoculated	70.1 c	95.7 c	82.9
Prosaro, non-inoculated	80.1 ab	107.8 a	94.0
Non-sprayed, inoculated	79.1 b	98.9 bc	89.0
Prosaro, inoculated	85.8 a	107.5 ab	96.7
LSD (*P*=0.05)	5.99	8.81	
	Fusarium head blight index (%)		
Treatment:	After corn	After soybean	Average
Non-sprayed, non-inoculated	3.9 a	0.4 a	2.2
Prosaro, non-inoculated	0.5 b	0.1 b	0.3
Non-sprayed, inoculated	4.5 a	0.4 a	2.5
Prosaro, inoculated	0.7 b	0.2 b	0.5
LSD (*P*=0.05)	2.05	0.17	
	Contamination of grain by DON (ppm)		
Treatment:	After corn	After soybean	Average
Non-sprayed, non-inoculated	14.5 a	2.0 a	8.2
Prosaro, non-inoculated	3.9 c	1.0 b	2.4
Non-sprayed, inoculated	16.5 a	2.0 a	9.3
Prosaro, inoculated	8.2 b	1.5 ab	4.8
LSD (*P*=0.05)	3.87	0.53	

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

	Adjusted grain yield (bu/A) at 13.5% moisture		
Cultivar:	After corn	After soybean	Average
Otsego	77.8 b	96.4 b	87.1
Pioneer 25R34	80.7 ab	108.4 a	94.6
Pioneer 25R46	85.6 a	112.7 a	99.2
Truman	70.8 c	92.4 b	81.6
LSD (*P*=0.05)	6.60	7.46	
	Fusarium head blight index (%)		
Cultivar:	After corn	After soybean	Average
Otsego	5.8 a	0.5 a	3.2
Pioneer 25R34	2.6 b	0.2 b	1.4
Pioneer 25R46	0.8 c	0.2 b	0.5
Truman	0.5 c	0.1 b	0.3
LSD (*P*=0.05)	1.86	0.16	
	Contamination of grain by DON (ppm)		
Cultivar:	After corn	After soybean	Average
Otsego	16.6 a	3.9 a	10.3
Pioneer 25R34	8.4 b	0.9 bc	4.7
Pioneer 25R46	8.0 b	0. 6 c	4.3
Truman	10.0 b	1.1 b	5.6
LSD (*P*=0.05)	4.97	0.60	

EVALUATING THE EFFECTS OF QUINONE OUTSIDE INHIBITOR FUNGICIDES ON DON ACCUMULATION AFTER ADJUSTING FOR THE EFFECTS OF FHB AND *FUSARIUM GRAMINEARUM* BIOMASS IN SOFT RED WINTER WHEAT

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ABSTRACT

Quinone Outside Inhibitors (QoIs) are effective fungicides for foliar disease control in wheat, but are usually not recommended for Fusarium head blight (FHB) and deoxynivalenol (DON) management, as some members of this group have been reported to increase DON in the grain. However, reasons for such a response are largely unknown. In particular, in-planta evaluation of the effects of QoI fungicides on DON is complicated by the fact that DON contamination is often positively correlated with FHB symptom development and grain colonization with *F. graminearum*. Consequently, high DON levels in QoI-treated plots may be due in part to correspondingly high levels of FHB and/or grain colonization, resulting from the relatively poor efficacy of this group of fungicides against this disease. The confounding effect of FHB on DON response to QoI may lead to inconsistent results across studies. Field and greenhouse experiments were conducted to determine the effects two QoI active ingredients have on DON, after adjusting for the effects of FHB index (IND), *Fusarium* damaged kernel (FDK), and fungal biomass. QoI fungicide treatments consisted of 23.6% pyraclostrobin applied at Feekes growth stages 8-9 (H_8), 10 (H_10), and 10.5.1 (H_10.5.1) and 7% azoxystrobin at Feekes 8-9 (Q_8), 10 (Q_10) and 10.5.1 (Q_10.5.1). A demethylation inhibitor fungicide, 19% tebuconazole + 19% prothioconazole, applied at the same three growth stages (P_8, P_10, and P_10.5.1), plus an untreated check, were included as reference treatments. All plants were inoculated with a spore suspension of *F. graminearum* at anthesis, IND and FDK were rated, and a sample of grain assayed for DON and FBM. Linear mixed model covariance analyses were used to model IND/logDON and FDK/logDON relationships and compare mean logDON among treatments at fixed levels of IND or FDK. All fungicide AIs applied at Feekes 10.5.1 resulted in significantly lower arcIND than the check. P_10.5.1 consistently had the lowest levels of DON, IND, and FDK. Under field conditions, QoIs did not have a significant effect on FDK. QoIs at Feekes 8 (H_8 and Q_8) did not have an effect on IND or logDON. Both H_10.5.1 and Q_10.5.1, as well as Q_10 had significantly higher logDON than the check and the P_10.5.1 treatment, for a given level of disease, under field conditions, but not in the greenhouse. Among the QoI treatments, azoxystrobin applied at Feekes 10 consistently resulted in higher DON and FBM than the check under both field and greenhouse conditions, but this effect was not always statistically significant. These results suggest that both QoIs at Feekes 10.5.1 and 7% azoxystrobin at Feekes 10 have the potential to increase DON in wheat grain, however, both may be useful options for foliar disease management earlier in the growing season without affecting DON.

AKNOWLEDGEMENTS AND DISCLAIMER

This material is based upon work supported by the U.S. Department of Agriculture, under Agreement No. 59-0206-9-071. 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.

IMPACT OF PREDICTION TOOLS FOR FUSARIUM HEAD BLIGHT IN THE US, 2009-2013

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ABSTRACT

A multi-state effort to predict epidemics of Fusarium head blight (FHB) continued during the 2009-2013-growing seasons. This prediction effort includes web-based tools, which display daily estimates of disease risk for 30 states. Commentary developed by a disease specialist in each state covered by the tool is displayed along with the risk maps. Commentary is also distributed via an FHB Alert System that sends email and text messages to mobile devices. The prediction tools received over 20,883 visits (122,000 hits) during the 2013-growing season in the U.S. (April – August). Nearly all of the wheat disease specialists in the 30 states covered by the disease prediction system contributed commentary to the disease prediction effort. A total of 126 commentaries were submitted in 2013. The FHB Alert System sent commentary to just under 1,000 subscribers in 2013. Users of the FHB prediction models and the FHB Alert System were surveyed annually in 2009-2012. The survey results included input from 1,828 respondents and indicated that 64% of these users were either farmers or farm advisors. More than 70% of the users applied the information directly on their farm, or used it to make recommendations to others about disease management. In 2009-2012, 95% of the users considered the information to be of high or moderate value for their farm operations and businesses. A subset of questions targeting the influence of the information suggests that more than 90% of the users experienced moderate or great improvement in their awareness of the disease risk in their area. The results also showed that the information influenced disease management decisions directly for 35% of the respondents, and motivated another 28% to seek advice from others. The 2012 survey asked growers to estimate the monetary value of the information provided to their farm or business. This survey indicates that the average monetary value of the information provided by the prediction system was $17,000 per user. Combining this figure with use statistics suggests that annual impact of the FHB prediction model exceeds $170 million.

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EVALUATION OF SEQUENTIAL FUNGICIDE PROGRAM IN WHEAT AND BARLEY

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ABSTRACT

The objective of this study was to evaluate a sequential fungicide program on controlling Fusarium head blight (FHB) and deoxynivalenol (DON) contamination in hard red spring wheat and barley. Misted experiments, randomized complete block design with six replications, were established at Langdon Research Extension Center in summer 2013. Plot size was 15 x 5 feet. Plots were artificially inoculated with corn spawn inoculum at around boot stage. The fungicide treatments evaluated were 1) untreated, 2) Caramba® at Feekes 10.51, 3) Prosaro® at Feekes 10.51, 4) Headline® at Feekes 5 followed by Caramba at Feekes 10.51, 5) Priaxor® at Feekes 5 followed by Caramba at Feekes 10.51, 6) Tilt® at Feekes 5 followed by Prosaro at Feekes 10.51, and 7) Priaxor at Feekes 5 followed by Twinline® at Feekes 9 and Caramba at Feekes 10.51. For barley Feekes 10.51 application was applied at Feekes 10.5. Fungicide treatments were applied at the recommended rate with water volume of 10 GPA. In wheat, the FHB severity 28 days after treatment (DAT) was significantly lower in treatments 3, 6 and 7 compared to that of untreated. DON level was significantly lower than untreated in treatments 2, 3, 5, and 7. No significant treatment effect was observed for yield and test weight. In barley, All treatments resulted in significantly lower 21 DAT FHB severity compared to untreated. Only treatments 3, 4, and 5 resulted in significantly lower 28 DAT FHB severity compared to control. DON level was significantly lower than untreated only in treatment 6. Treatments were not significantly different for plump kernel percent and yield.

2013 FIELD PLOT TRIAL FOR BIOLOGICAL CONTROL OF FUSARIUM HEAD BLIGHT IN SOUTH DAKOTA USING *BACILLUS AMYLOLIQUEFACIENS* STRAINS

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ABSTRACT

Fusarium Head Blight (FHB) or Wheat Scab, caused by *Fusarium graminearium* is an economically important disease of wheat and barley. Yield losses can 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 to analyze the efficacy of *Bacillus amyloliquefaciens* strains 1BA and 1D3 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 were done on Briggs spring wheat heads at Feekes 10.51. No statistically significant treatment differences were observed for FHB incidence, severity and index. The combination of *Bacillus* 1BA, plant oil, colloidal chitin and Prosaro reduced the FHB incidence to 3.17%, which was less than the FHB incidence observed for Prosaro alone (5.91%) or for the untreated control (17.08%). The treatment combination of *Bacillus* strains 1BA, 1D3, plant oil, colloidal chitin and Prosaro reduced the FHB severity to 3.64%, which was less than the FHB severity observed for Prosaro alone (7.81%) or the untreated control (17.01%). The treatment of *Bacillus* strain 1BA with plant oil, colloidal chitin and Prosaro reduced the disease index to 0.6%, while the treatment of *Bacillus* strains 1BA and 1D3 with plant oil, colloidal chitin, and Prosaro reduced the disease index to 0.53%. The treatment of Prosaro alone reduced the FHB disease index to 0.77%, while for the untreated control it was observed to be 2.84%. Several treatments with the BCAs showed significant differences (P=0.05) for test weight and yield in comparison to the untreated control. The DON data are not yet available as of November 2013. This trial demonstrated that *Bacillus* strains 1BA or 1D3 in combination with Prosaro and/or colloidal chitin can reduce FHB in wheat, more than a single application of Prosaro.

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WIN EXPERIENCE WITH DON FORECASTING IN CANADA, EUROPE

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ABSTRACT

Weather INnovations Consulting, LP (WIN), based in Chatham, Ontario, Canada, provides turnkey online programs in climate and environmental monitoring and modelling, primarily for agriculture. WIN builds web-based agronomic solutions for growers that help them deal more proactively with the weather's influences on farming. WIN's website for Ontario grain growers, *WeatherCentral.ca,* offers site-specific weather forecasts, disease and insect risk advisories, growth stage models and includes tools targeted at *Fusarium*-related issues. The DONcast® model, for instance, predicts deoxynivalenol toxin concentration in wheat at harvest during the heading stage to assist growers with fungicide application decisions. DONcast® examines observed, forecasted and historical weather data, along with field-specific agronomic data, and updates predictions daily through to harvest time which assists growers in strategizing which fields with elevated DON potential should be harvested first.

WIN develops tools like DONcast® through research and development collaborations with industry, universities and other stakeholders. A variation of the DONcast® model has been calibrated for European conditions with support from Bayer CropScience. WIN's European modeling activity includes forecasts of several major *Fusarium* species which helps refine the prediction of mycotoxin contamination in wheat. Dr. Rishi Burlakoti, one of WIN's plant pathologists, is now concluding a collaborative Canadian chemotyping study with researchers from the University of Guelph and Agriculture and Agri-Food Canada that examined multiple strains of *Fusarium graminearum* from wheat, potato and corn with respect to geographic locations/years and weather variables.

Ian Nichols, WIN's founder and president, will present an overview of WIN's efforts in providing advisories for agricultural producers with respect to FHB.

FHB INTEGRATED MANAGEMENT: A 2013 UPDATE

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ABSTRACT

Experiments were established in fields previously planted with host or non-host crops of *F. graminearum* (*F.g*) to evaluate the integrated effects of fungicide and genetic resistance on FHB and DON in small grain crops under different environmental conditions. 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). In some trials, a split-split plot design as used with cultivar as whole-plot and fungicide or fungicide x inoculation combination as sub-plot. In some trials established in *F.g* host crop residue, plots were not artificially inoculated. 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 and/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 (IND, plot severity) was assessed during the dough stages of grain development, and at harvest, grain samples were sent to a USWBSI-supported laboratory for mycotoxin analysis. At the time of this report, data were collected from 19 experiments, four from MD, three each from IL and SD, two each from NY and MO, one each from AR, OH, IN, NB and WI. Fifteen of the experiments were conducted with SRWW, two with HRWW and one each with HRSW and barley. Percent control ($([\bar{X}_{S\_UT} - \bar{X}_{MGNT\ COMBO}] / \bar{X}_{S\_UT}) \cdot 100$) was calculated as a measure of the efficacy of different cultivar resistance + fungicide management combinations (S_TR, MS_UT, MS_TR, MR_UT and MR_TR) against IND and DON relative to the susceptible, untreated check (S_UT). In six of the 19 experiments, mean index in the S_UT treatment combination was less than 2%. The highest level of disease were observed in IL, MO and NE. Averaged across experiments and grain classes, mean percent control in IND was 77% for MR_TR, 54% for MR_UT, 45% for MS_TR, 13% for MS_UT and 35% for S_TR. For DON, the corresponding percentages were 71, 52, 59, 47, and 26%, for MR_TR, MR_UT, MS_TR, MS_UT and S_TR, respectively.

The full report will be available by mid-January 2014 through the Scab Website (www.scabusa.org).

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IMPLICATIONS OF RAINFALL AT ANTHESIS FOR SCAB MANAGEMENT WITH FUNGICIDES

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ABSTRACT

Not only is rainfall during anthesis conducive to Fusarium head blight (FHB) development and deoxynivalenol (DON) accumulation, it also affects the implementation and efficacy of one of the most important FHB management strategies, fungicide treatment application. Rainfall simulators were used to study the effects of rainfall treatments applied at intervals ranging from 15 to 195 minutes after Prosaro® application on the efficacy of this fungicide against FHB index (IND) and DON and the presence of residue of tebuconazole, one of the active ingredients in Prosaro, on wheat spikes. In addition, field experiments were conducted in Ohio and Illinois to evaluate the efficacy of post-anthesis applications of Prosaro and Caramba® for FHB and DON management. In four of five simulated rainfall experiments, all fungicide-treated experimental units (EUs) had significantly lower mean IND and DON than the untreated check, regardless of rainfall treatment. EUs that received the earliest rains (15, 30 and 60 minutes after fungicide application) tended to have the highest mean IND and DON, but were generally not significantly different from EUs that received later rainfall (105 to 195 minutes after fungicide treatment) or EUs treated with the fungicide without being subjected to simulated rain. Tebuconazole residue on wheat spikes decreased exponentially over time, with the greatest rate of reduction occurring during the first eight days after application. When applied with the non-ionic surfactant Induce, Prosaro appeared to be very rainfast for the fixed set of rainfall characteristics evaluated in this study, and tebuconazole residue did not persist very long after application on wheat spikes. Results from experiments in which fungicide treatments were applied at anthesis or at 2, 3, 4, 5 or 6 days after anthesis showed that both anthesis and post-anthesis treatments resulted in significantly lower mean IND, FDK and DON than the untreated check. Mean IND and DON were either not significantly different between anthesis and post-anthesis treatments or were significantly lower for some post-anthesis treatments in experiments in which it rained or conditions were unseasonably cold during anthesis. Results were consistent for Prosaro and Caramba, and across cultivars. Mean percent control of IND and DON for post-anthesis treatments were 62 and 45%, respectively, compared to 57 and 39%, respectively, for anthesis treatments.

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2013 UNIFORM FUNGICIDE PERFORMANCE TRIALS FOR THE SUPPRESSION OF FUSARIUM HEAD BLIGHT IN SOUTH DAKOTA IN HARD RED SPRING WHEAT

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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 evaluate the effects of various fungicides and fungicide combinations at different application timings for the suppression of Fusarium head blight and other wheat diseases in hard red spring wheat. Two hard red spring wheat cultivars, 'Brick' and 'WB Mayville', were planted at three South Dakota locations (Groton, 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 included an untreated check and the following fungicides: Applied at Feekes growth stage 10.51: Prosaro® (6.5 fl oz/A), Caramba® (14 fl oz/A), Tebucon® (4 fl oz/A), Tebucon (4 fl oz/A) + Caramba (10 fl oz/A) and Tebucon (4 fl oz/A) + Thymol (10 g/A); Applied at 3-7 days after Feekes growth stage 10.51: Prosaro (6.5 fl oz/A) and Caramba (14 fl oz/A). All treatments included Induce, a non-ionic surfactant, applied at 0.125% v/v. The experimental design was a split plot in randomized complete block with six replications. Main plots were the two cultivars and subplots were the fungicide treatments. Wheat plots at the Volga location were inoculated by spreading *Fusarium graminearum* (isolate Fg4) infected 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 no misting. Twenty-one days following treatment, plots were evaluated for leaf diseases, FHB incidence, FHB head severity, FHB field severity, and FHB disease index (FHB incidence x severity). Samples were collected for *Fusarium* damaged kernels (FDK), deoxynivalenol (DON), grain yield and test weight.

No significant effect of treatments for FHB incidence, FHB severity and FHB disease index were found at the South Shore/Watertown location but four treatments (Prosaro applied at Feekes 10.51, Tebucon applied at Feekes 10.51, Tebucon + Caramba applied at Feekes 10.51 and Caramba applied at 3-7 days after Feekes 10.51) were significant in reducing FDK levels. At the Groton location, there were three treatments significant in reducing FHB incidence (Tebucon applied at Feekes 10.51, Tebucon + Caramba applied at Feekes 10.51 and Caramba applied at 3-7 days after Feekes 10.51. Also at the Groton location, all of the treatments reduced FHB disease index. At the Volga location, all treatments except for the Tebucon, significantly reduced FHB incidence. Only Caramba applied at Feekes 10.51 and Caramba applied at 3-7 day after Feekes 10.51 reduced FHB severity at Volga location. At the Volga location, all of the treatments except the Tebucon treatment were significant at reducing the FHB disease index and all of the treatments except Tebucon and Tebucon + Thymol were significant in reducing FDK.

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PRELIMINARY ECONOMIC ANALYSIS OF FHB MANAGEMENT STRATEGIES

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ABSTRACT

The use of moderately resistant cultivars integrated with Prosaro® or Caramba® application and cultural practices has been very effective at reducing Fusarium head blight (FHB), deoxynivalenol (DON), as well as grain yield and quality losses caused by this disease. However, under highly favorable weather conditions, even when the best management options are implemented, yield and quality (test weight of grain, *Fusarium* damaged kernel [FDK] and DON contamination) losses still occur, leading to price discounts or dockage. But not using a fungicide when it is most warranted may result in even larger reductions in yield and quality. On the other hand, when FHB is low, losses may be minimal; consequently, applying a fungicide may reduce a grower's income because the application cost may not be recouped. There is therefore a need for information regarding the economic value of implementing FHB management strategies that could be used to help growers make more informed management decisions. Different combinations of cultivar FHB reaction (MR = moderately resistant and S = susceptible), Prosaro fungicide treatment (TR = treated and UT = untreated) and grain harvesting strategy (C1 = default and C2 = modified to remove scabby grain) were combined to derive 8 different FHB management programs: P1 = MR+TR+C2, P2 = MR+UT+C2, P3 = S+TR+C2, P4 = S+UT+C2, P5 = MR+TR+C1, P6 = MR+UT+C1, P7 = S+TR+C1, and P8 = S+UT+C1. P8 (without any management intervention) served as the reference program. Relative to P8, the greatest percent reduction in FDK and DON and increase in yield was observed for programs that included a Prosaro fungicide treatment (P1, P3, P5 and P7). The greatest percent increase in test weight relative to P8 was observed when C2 was integrated with MR and TR. The effects of different management programs on IND/yield and IND/test weight relationships was evaluated through linear mixed model covariance analysis, showing that programs affected the height but not the slopes of the IND/yield and IND/test weight regression lines. Predicted yield, test weight, FDK, and DON for P8 for a range of index values (5, 10 and 20%); percent FDK and DON reduction and percent yield and test weight increase for the four best management programs (P1, P3, P5 and P7) relative to P8; a range of estimated grain prices and price discounts; and a range of fungicide application costs were used to conduct a cost/benefit analysis of each of the management programs. Preliminary results showed that under moderate to high IND levels (10 and 20%), management programs that include an MR cultivar and Prosaro application (P1 and P5) consistently had lower grain price discounts (US$/MT of grain) and higher gross cash income (US$/ha) than other management programs. The use of modified combine configuration (C2) was most beneficial for lowering price discounts when either a MR cultivar or the Prosaro treatment was not implemented, IND levels were high (10 and 20%), and estimated grain prices were high (US$ 197 and 276/MT).

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