Best-Management Practices for FHB and DON: A 2014 Multi-State Project Update

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OBJECTIVE

Evaluate the integrated effects of fungicide and genetic resistance on FHB and DON in all major wheat classes, with emphasis on different application timings and new genotypes to develop more robust "*best-management practices*" for FHB and DON.

INTRODUCTION

Over the last 15 years, considerable progress has been made to develop management strategies to minimize FHB-associated grain yield and quality losses in wheat and barley. Several new resistant cultivars have been developed, efficacious fungicides registered, accurate disease forecasting models deployed to help guide fungicide applications, and the value of integrating multiple in-field and grain harvesting strategies to manage this disease-toxin complex has been demonstrated (Salgado et al., 2014; Willyerd et al., 2012; McMullen et al., 2012). For instance, results from several years of coordinated integrated management trials showed that relative to the untreated susceptible check, the combination of moderately resistant cultivar and Prosaro application at anthesis resulted in more than 70% control of both FHB index and DON (Willyerd et al., 2012). However, weather conditions, fungicide and spray associated costs, cultivar yield potential and other factors often prevent the adoption of current management recommendations. For instance, wet, soggy field conditions may make it impossible for ground applications of fungicides at the recommended anthesis growth stage. Moreover, even if such applications are made, research shows the rainfall during or shortly after treatment may reduce fungicide efficacy (Andersen et al., 2014). Delaying application for up to six days after flowering to avoid rain and other adverse conditions was shown to provide good levels of FHB and DON reduction in soft red winter wheat in Illinois and Ohio (D'Angelo et al., 2014). However, further research is needed to evaluate the efficacy of post-anthesis application in other locations and wheat classes, as well as the integrated effects of "late" applications and cultivar resistance.

MATERIALS AND METHODS

Field experiments were established in 12 US wheat-growing states (AR, DE, IL, IN, MD, MI, MN, ND, NE, NY, OH and SD) to investigate the effects of cultivar resistance and fungicide application

timing on FHB and DON. Plots were established following host or non-host crops of *F. graminearum*, according to standard agronomic practices for each location. At least three commercial wheat cultivars, classified as susceptible (S), moderately susceptible (MS), or moderately resistant (MR), were planted in most trials. However, some trials only included one or two of these resistance categories. Plots were planted in four to six replicate blocks. The standard experimental design was a randomized complete block, with a split-plot arrangement of cultivar as whole-plot and fungicide (Prosaro, 6.5 fl. oz/A + NIS) application timing as sub-plot (untreated or treated at anthesis [A] or 2 to 7 days post-anthesis [A+2 … A+7, respectively]). All plots were artificially inoculated with either *F. graminearum*-colonized corn kernels spread on the soil surface or spray-inoculated with a spore suspension of the fungus approximately 24-36 hours following the anthesis fungicide treatment. FHB index (plot severity) was assessed during the soft dough stages of grain development. Milled grain samples were sent to a USWBSI-supported laboratory for toxin analysis. For the purpose of this report, percent control of FHB index and DON was estimated for each cultivar x fungicide application timing combination relative to the untreated susceptible check, and the best management practice, based on percent control, was highlighted for each trial/ environment.

RESULTS AND DISCUSSION

Data from 14 trials, representing seven soft red winter wheat, two hard red winter wheat, four hard red spring wheat, and one soft white winter wheat classes are summarized in Table 1. Means for each cultivar resistance class x fungicide application timing combination are shown in Table 1. Mean FHB index in the untreated susceptible check ranged from 0 to 49%, and mean DON from 0.5 to 15.6 ppm. In some locations, FHB did not develop due to unfavorable weather conditions. In addition, DON data were not available for some trials at the time of this report, therefore trials with missing data or nominal disease and toxin levels (< 4% index and < 2 ppm DON, Table 1) were not used to estimate percent control. Percent control of FHB index and DON, relative to the untreated susceptible check is shown in Figs. 1 and 2 for trials with the highest levels of mean index and DON in the check (and where possible, representative of each market class). The best management combinations, based on the highest percent control of index, for trials/environment with index > 4% are presented in Fig. 3.

Fungicide alone reduced FHB index and DON in each resistance category and wheat market class, however, the combination of cultivar resistance and fungicide application was most effective at reducing FHB and DON in most trials (Table 1 and Figs. 1-3, in 8 out of 11 trials reporting FHB index > 4%). In some cases (ENV = 3, 8 and 9) fungicide-treated MS cultivars had the highest percent control of both FHB and DON, and post-anthesis treatments in ENV 3, 8, 9, 10, and 13 were as effective as or more effective than anthesis treatments (Figs. 1-3). Based on these results, there is evidence suggesting that applying fungicides post-anthesis may be as efficacious against FHB and DON as treatments applied at anthesis in all wheat classes and environments.

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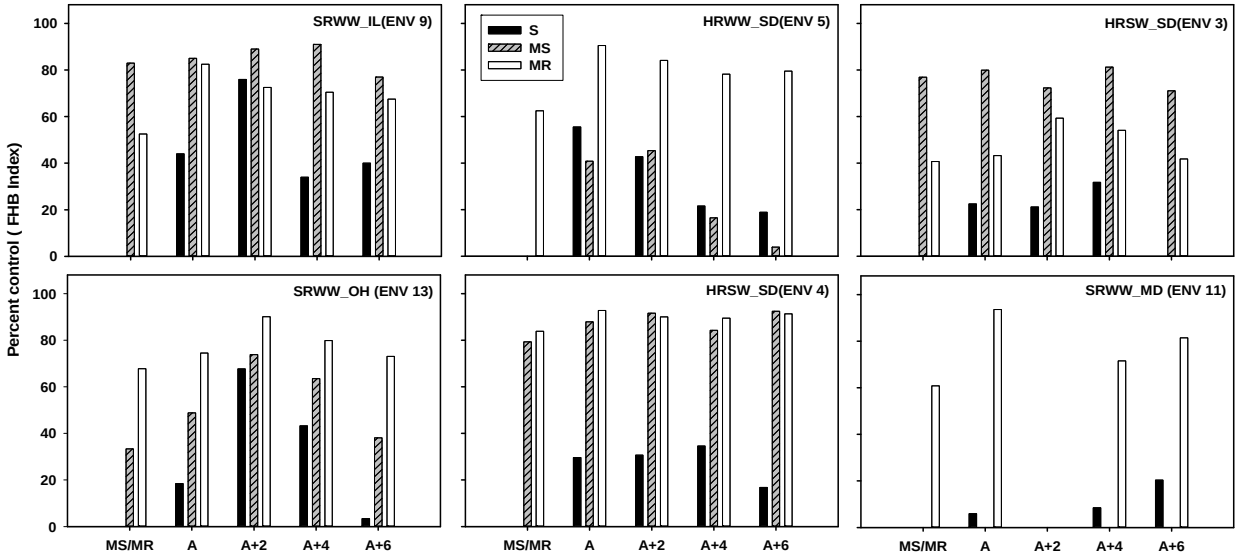

Fig. 1. Percent control of FHB index relative to the untreated susceptible check (Table 1) for different FHB management combinations in three different wheat classes (HRWW, HRSW, and SRWW). Cultivar resistance (susceptible, S; moderately susceptible, MS; and moderately resistant, MR). MS/MR, represents the effect of cultivar resistance alone (untreated MR or MS cultivar).

Prosaro (6.5 fl oz/A) was applied either at anthesis (A), or 2, 4, or 6 days post-anthesis (A+2, A+4 or A+6, respectively).

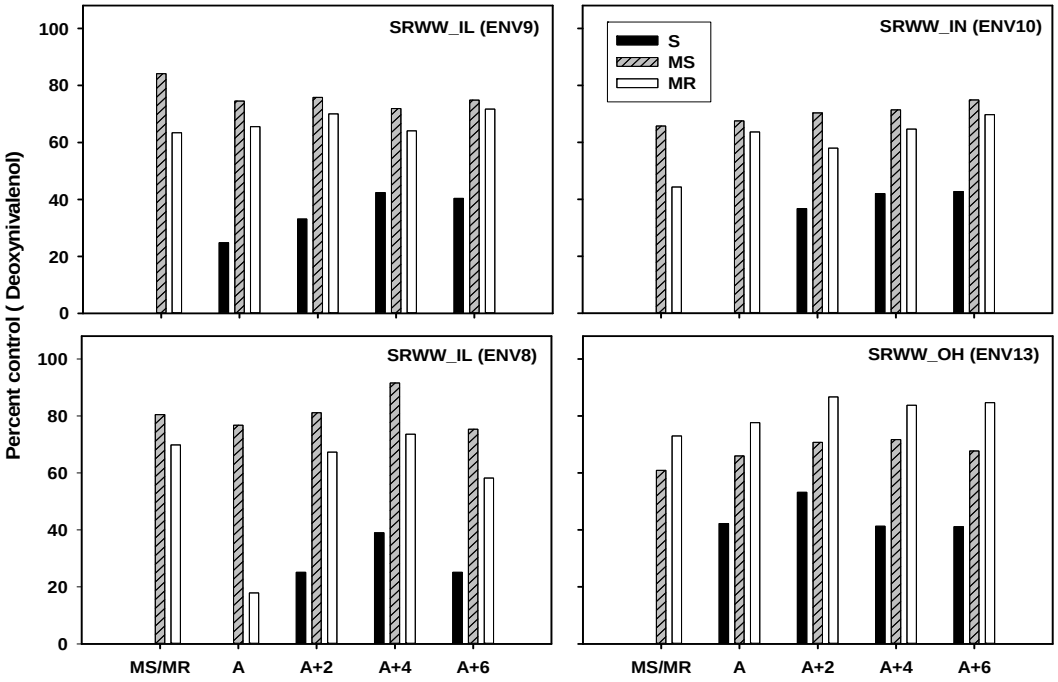

Fig. 2. Percent control of DON relative to the untreated susceptible check (Table1) for different FHB management combinations in trials with mean DON check > 2 ppm. Cultivar resistance (susceptible, S; moderately susceptible, MS; and moderately resistant, MR). MS/MR, represents the effect of cultivar resistance alone (untreated MR or MS cultivar). Prosaro (6.5 fl oz/A) was applied either at anthesis (A), or 2, 4, or 6 days post-anthesis (A+2, A+4 or A+6, respectively).

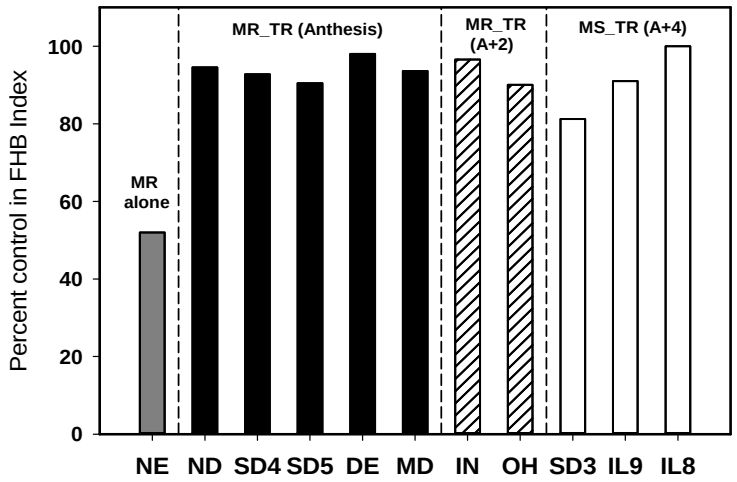

Fig. 3. Percent control of FHB index relative to the untreated susceptible check for the best management combinations in environments that reported FHB index in the susceptible untreated check above 4% (Table 1). Environments are grouped based on the cultivar x fungicide application timing combination with the highest percent control. Cultivar FHB resistance reaction (moderately susceptible, MS; and moderately resistant, MR). Plots were treated (TR) with Prosaro (6.5 fl oz/A)

either at anthesis (A), or 2, 4, or 6 days post-anthesis (A+2, A+4 or A+6, respectively). MR alone = the effect of moderate resistance in the absence of fungicide.

Table 1. Mean FHB index and DON for different cultivar x fungicide timing management combinations from 14 coordinated integrated management trials (ENV, environments) representing different wheat classes (TYPE = HRWW, HRSW, SRWW and SWWW). Results are organized by cultivar FHB resistance reaction (susceptible, S; moderately susceptible, MS; and moderately resistant, MR) and fungicide treatment (untreated [No] or treated [TR] at anthesis [Yes] or 2, 4, 5, 6 or 7 days post-anthesis.

				Susceptible (S)							Moderately Susceptible (MS)							Moderately Resistant (MR)						
				[C]Anthesis TR		Post anthesis TR (days)					Anthesis TR		Post anthesis TR (days)					Anthesis TR		Post anthesis TR (days)				
Response	ENV	LOCATION	TYPE	No	Yes	2	3	4	5	6	No	Yes	2	4	5	6	7	No	Yes	2	4	5	6	7
FHB Index [a]	1	Langdon, ND	HRSW	10.1	4.6	…	…	…	2.1	…	…	…	…	…	…	…	…	1.7	0.6	…	…	1.6	…	…
(%)	2	Fargo, ND	HRSW	0.0	0.1	…	…	…	0.0	…	0.0	0.0	…	…	0.0	…	…	0.0	0.0	…	…	0.5	…	…
	3	Volga, SD	HRSW	48.8	37.8	38.4	…	33.3	…	50.6	11.3	9.8	13.5	9.2	…	14.1	…	28.9	27.7	19.8	22.4	…	28.4	…
	4	South Shore, SD	HRSW	18.8	13.2	13.0	…	12.3	…	15.6	3.9	2.3	1.6	3.0	…	1.4	…	3.0	1.4	1.9	2.0	…	1.6	…
	5	Volga, SD	HRWW	19.0	8.5	10.9	…	14.9	…	15.4	30.6	11.3	10.4	15.9	…	18.3	…	7.2	1.8	3.0	4.2	…	3.9	…
	6	Mead, NE	HRWW	3.1	3.1	2.4	…	2.4	…	2.7	…	…	…	…	…	…	…	1.5	1.6	1.7	1.8	…	1.8	…
	7	Georgetown, DE	SRWW	7.0	4.9	…	…	4.1	…	3.3	…	…	…	…	…	…	…	0.4	0.1	…	0.7	…	0.3	…
	8	Dixon Springs, IL	SRWW	7.3	8.5	3.8	…	0.7	…	1.1	1.6	1.1	0.6	0.0	…	0.7	…	1.9	3.0	1.9	1.7	…	0.8	…
	9	Urbana, IL	SRWW	12.5	7.0	3.0	…	8.3	…	7.5	2.1	1.9	1.4	1.1	…	2.9	…	5.9	2.2	3.4	3.7	…	4.1	…
	10	West Lafayette, IN	SRWW	4.4	2.3	1.8	…	2.8	…	1.7	0.5	0.4	0.4	0.5	…	0.2	…	0.4	0.2	0.1	0.1	…	0.5	…
	11	Wye, MD	SRWW	13.2	12.4	…	…	12.0	…	10.5	…	…	…	…	…	…	…	5.2	0.8	…	3.7	…	2.4	…
	12	Aurora, NY	SRWW	…	…	…	…	…	…	…	4.2	1.8	…	…	…	…	0.5	1.0	0.8	…	…	…	…	0.3
	13	Wooster, OH	SRWW	12.6	10.3	4.1	…	7.2	…	12.2	8.4	6.5	3.3	4.6	…	7.8	…	4.1	3.2	1.3	2.5	…	3.4	…
	14	Deckerville, MI	SWWW	0.6	0.3	…	0.1	…	…	0.2	…	…	…	…	…	…	…	…	…	…	…	…	…	…
DON [b] (ppm)	6	Mead, NE	HRWW	0.6	1.2	0.8	…	1.1	…	0.7	…	…	…	…	…	…	…	0.6	0.6	1.3	0.9	…	0.9	…
	7	Georgetown, DE	SRWW	2.0	1.2	…	…	1.2	…	1.2	…	…	…	…	…	…	…	0.3	0.3	…	0.2	…	0.2	…
	8	Dixon Springs, IL	SRWW	4.0	7.9	3.0	…	2.4	…	3.0	0.8	0.9	0.8	0.3	…	1.0	…	1.2	3.3	1.3	1.1	…	1.7	…
	9	Urbana, IL	SRWW	7.6	5.7	5.1	…	4.4	…	4.5	1.2	1.9	1.8	2.1	…	1.9	…	2.8	2.6	2.3	2.7	…	2.1	…
	10	West Lafayette, IN	SRWW	7.1	7.3	4.5	…	4.1	…	4.1	2.4	2.3	2.1	2.0	…	1.8	…	3.9	2.6	3.0	2.5	…	2.1	…
	11	Wye, MD	SRWW	1.9	1.6	…	…	1.1	…	0.9	…	…	…	…	…	…	…	0.6	0.5	…	0.4	…	0.3	…
	12	Aurora, NY	SRWW	…	…	…	…	…	…	…	3.2	1.3	…	…	…	…	0.8	1.3	0.5	…	…	…	…	0.2
	13	Wooster, OH	SRWW	15.6	9.0	7.3	…	9.1	…	9.2	6.1	5.3	4.6	4.4	…	5.0	…	4.2	3.5	2.1	2.5	…	2.4	…
	14	Deckerville, MI	SWWW	0.5	0.5	…	0.1	…	…	0.1	…	…	…	…	…	…	…	…	…	…	…	…	…	…

[a]FHB index = mean proportion of diseased spikelets per spike.

[b]DON = deoxynivalenol content of harvested grain in ppm.

[c]Fungicide application = Prosaro applied at 6.5 fl. oz./A + NIS at or after anthesis.