Fusarium Head Blight Management Coordinated Project: Integrated Management Trials 2022-2024

Comparative Assessment of Host Resistance and New Fungicides for Managing Fusarium Head Blight (FHB) and Deoxynivalenol (DON) in Wheat

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Introduction: Integrated approaches for managing Fusarium head blight (FHB) and deoxynivalenol (DON) contamination of wheat grain include the use of agronomic practices such as tillage, crop rotation, and cultivar resistance in combination with a timely fungicide application. Demethylation inhibitor (DMI) active ingredients (AIs) such as prothioconazole, metconazole, and tebuconazole have historically provided the most effective control of FHB and DON. The current industry standards for FHB and DON management are Prosaro, a premix of two DMI AIs (tebuconazole and prothioconazole), and Miravis® Ace, a combination of the DMI propiconazole and the SDHI Pydiflumetofen. Questions have arisen about whether newly registered fungicides like Prosaro Pro (a premix of the DMIs tebuconazole and prothioconazole and the SDHI Fluopyram) and Sphaerex (a combination of metconazole and prothioconazole) can match or surpass the efficacy of these established products in integrated management programs. The focus of the integrated management coordinated project (IM_CP) during the 2022, 2023 and 2024 growing seasons was to determine whether Prosaro Pro and Sphaerex were as effective as Prosaro and Miravis Ace against FHB and DON when used alone or as part of integrated management programs.

Materials and Methods: During the 2022, 2023 and 2024 growing seasons, field experiments were conducted across 20 US wheat-producing states. The experiments followed a standard protocol, where the fungicide treatments outlined in Table 1 were applied to separate plots of wheat cultivars with varying levels of resistance to FHB: susceptible (S), moderately susceptible (MS), and moderately resistant (MR). The combinations of fungicide treatments and cultivar resistance classes were designated as follows: MR_CK (nontreated MR), MR_I (MR treated with Prosaro at early anthesis [Feekes 10.5.1]), MR_II (MR treated with Miravis Ace at early anthesis), MR_III (MR treated with Prosaro Pro at early anthesis), and MR_IV (MR treated with Sphaerex at early anthesis). Corresponding combinations for the MS and S cultivars were labeled MS_CK, MS_I, MS_II, MS_III, and MS_IV, and S_CK, S_I, S_II, S_III, and S_IV, respectively.

The experimental design was a randomized complete block with a split-plot arrangement of cultivar resistance as whole plot and fungicide treatment as sub-plot. There were at least four replicate blocks. In most trials, plots were spray-inoculated with a spore suspension of *Fusarium graminearum* approximately 24–36 hours after fungicide application at anthesis, with or without supplemental mist irrigation. At some locations, infections occurred naturally (no artificial inoculation). FHB index (IND) was assessed as previously described (1,5) on 60–100 spikes per plot at approximately Feekes 11.2. Following harvest, grain samples from each plot were processed and assayed for mycotoxins contamination at one of the USWBSI-supported testing laboratories.

Separate linear mixed models (multi-location analysis) were used to analyze the effects of management combinations on arcsine square root-transformed IND and log-transformed DON data, pooled across environments (trial × state × year combinations). Management combinations (15 levels) were treated as fixed effects, while environment, block nested within environment, and cultivar nested within block and environment were treated as random effects. Contrasts were used for pairwise comparisons of fungicide treatments within resistance classes and between management combinations and groups of management combinations of interest.

Table 1. Treatments that were randomly assigned to experimental units. All fungicide treatments included a nonionic surfactant at a rate of 0.125% (vol/vol)

Treatment	Product	Rate (fl oz/A)	Timing*
1 (CK)	Nontreated check	…	…
2 (I)	Prosaro	6.5	Feekes 10.5.1 (early anthesis)
3 (II)	Miravis Ace	13.7	Feekes 10.5.1 (early anthesis)
4 (III)	Prosaro Pro	10.3	Feekes 10.5.1 (early anthesis)
5 (IV)	Sphaerex	7.3	Feekes 10.5.1 (early anthesis)

*Early anthesis was defined as when approximately 50% of the tillers had fresh anthesis extruded in the center of the spikes

Results and Discussion:

Distributions of (FHB) index and DON: Figure 1. illustrates the distribution of mean FHB IND and DON for various treatment combinations across environments (location_years). These

environments represented spring- and winter wheat-growing regions, spanning five wheat market classes: durum, hard red spring, hard red winter, soft red winter, and soft white winter.

Mean IND varied across environments and management combinations, ranging from 0 to 60% (**Fig. 1A**). Similarly, mean DON contamination of grain ranged from 0 to 25 ppm across environments and management combinations (**Fig.1B**). Among nontreated checks, the moderately resistant nontreated check (MR_CK) exhibited a relatively narrower interquartile range (IQR) of 2.7% for FHB IND with 50% of the values falling between 0.2 to 2.9%. In contrast, the susceptible nontreated check (S_CK) had a wider IQR range of 12.1% and the highest mean IND of 13.3%, with half of the values falling between 0.5 to 12.6%. A similar pattern was observed for DON contamination, with the MR_CK showing the narrowest IQR range of 1.7 ppm, followed by the moderately susceptible check (4.3 ppm). S_CK exhibited the widest IQR of 4.9 ppm for DON with a mean of 3.7 ppm and half of the values between 0.3 to 5.3 ppm. Treatment combinations that involved an application of Prosaro, Miravis Ace, Prosaro Pro, or Sphaerex at anthesis to MR cultivars resulted in the lowest mean IND values (1.3, 0.9, 1.2, and 1.3%, respectively) (Fig. 2A).

Fusarium head blight (FHB) index: S_CK had significantly higher mean IND (13.3%) than all other tested treatment combinations (Fig 2). Treatment combinations involving the application of Prosaro, Miravis Ace, Prosaro Pro, or Sphaerex at anthesis to moderately resistant cultivars had the lowest mean IND values. Mean IND was not significantly different among fungicide treatments when applied at anthesis to MR cultivars or MS cultivars. However, when applied to S cultivars, Miravis Ace resulted in significantly lower mean IND than the Prosaro, Sphaerex, and Prosaro Pro, and Prosaro Pro and Sphaerex resulted significantly lower mean IND than Prosaro.

Deoxynivalenol (DON): The susceptible nontreated check (S_CK) exhibited the highest mean DON contamination, approximately 3.9 ppm. As was the case with IND, the lowest mean DON levels were observed when Prosaro, Miravis Ace, Prosaro Pro, or Sphaerex were applied at anthesis to MR cultivars, with means ranging between 0.7 to 0.8 ppm. Among the nontreated checks, the highest mean DON level was recorded for S_CK (3.9 ppm), while the lowest was observed for MR_CK (1.7) (**Fig. 2B**). Within a given resistance class, all fungicide treatments resulted in significantly lower mean DON contamination than the nontreated check. Means that were not significantly different among treatments when applied to MR or MS cultivars, but significantly lower for Mirvis Ace than Prosaro when applied to S cultivars (**Fig. 2B**).

Efficacy of FHB management programs against IND and DON contamination of grain: Integrated management programs combining one of the tested fungicides with a moderately resistant cultivar provided the greatest efficacy against IND and DON contamination, with 87–92% control of IND and 77–80% control of DON compared to the nontreated susceptible check (S_CK) (Fig. 3). Programs involving a moderately susceptible cultivar treated with a fungicide showed intermediate efficacy, with 78–82% reduction in mean IND and 52–57% reduction in mean DON (Fig. 3). The least effective programs were those consisting of using susceptible cultivars treated with fungicides, which provided 55–71% control of IND and 51–62% control of DON (Fig. 3). For

both IND and DON, efficacy in terms of percent control relative to S_CK was comparable among fungicide treatments on MR or MS, but varied among treatments on S cultivars.

When evaluating fungicide-only management programs, i.e. fungicide treatments applied to susceptible cultivars, Miravis Ace, Sphaerex, and Prosaro Pro were more effective than Prosaro, the industry standard, based on percent control. Specifically, relative to Prosaro, Miravis Ace, Sphaerex, and Prosaro Pro reduced IND by 35, 36, and 25%, respectively. The trends were somewhat different for DON, with a reduction of approximately 21% relative to Prosaro for Miravis Ace, but only 5% for Sphaerex, and 0.6% for Prosaro Pro, respectively.

Based on the pooled data from 2022, 2023, and 2024, the newly released fungicides Prosaro Pro and Sphaerex were found to be as effective as the industry-standard Prosaro in reducing IND and DON when applied to moderately resistant or moderately susceptible cultivars as part of integrated management programs. However, on susceptible cultivars, Prosaro Pro and Sphaerex demonstrated greater efficacy than Prosaro against IND (in terms of percent control) but were of similar efficacy against DON. The experiments will be repeated during the 2025 growing season, and the data will be pooled and analyzed to quantify the effects of different management combinations more thoroughly.

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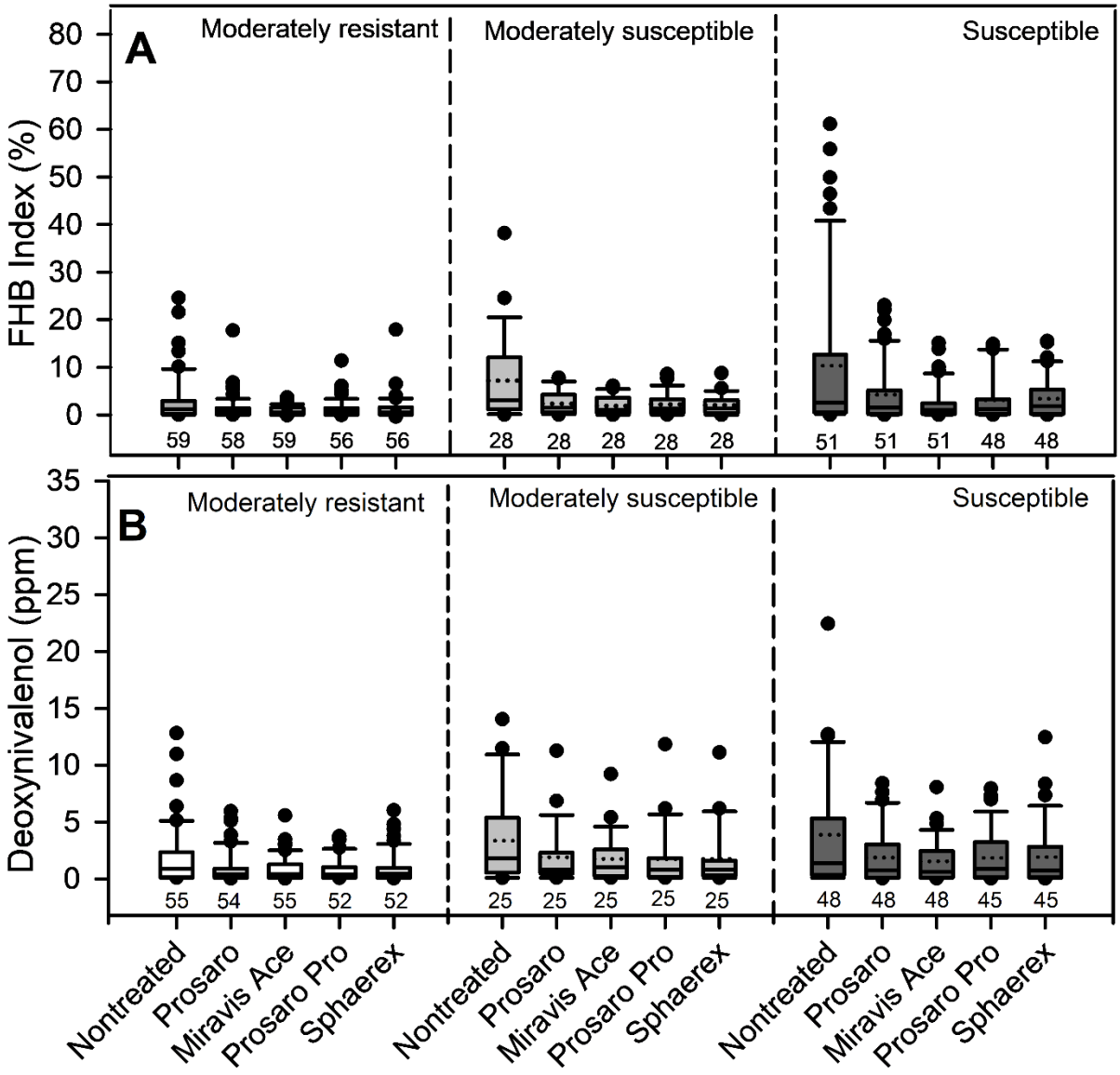

Fig. 1. Boxplots showing the distribution of least square mean Fusarium head blight (FHB) index (**A)**, and deoxynivalenol (DON) grain contamination (**B**) across different fungicide program x cultivar resistance management combinations. Cultivar resistance levels are indicated as susceptible, moderately susceptible, moderately resistant. The fungicide programs consisted of Prosaro at 6.5 fl. oz/acre, Miravis Ace at 13.7 fl. oz/acre, Prosaro Pro at 10.3 fl. oz/acre, and Sphaerex at 7.3 fl. oz/acre, all applied at anthesis, plus a nontreated check. Each bar represents the mean response averaged across trials from the 2022, 2023, and 2024 growing seasons. Horizontal dashed lines indicate the mean FHB index or DON contamination. Numbers above the x-axis represent the number of trials in which each fungicide treatment was evaluated for its effect on the respective response variables.

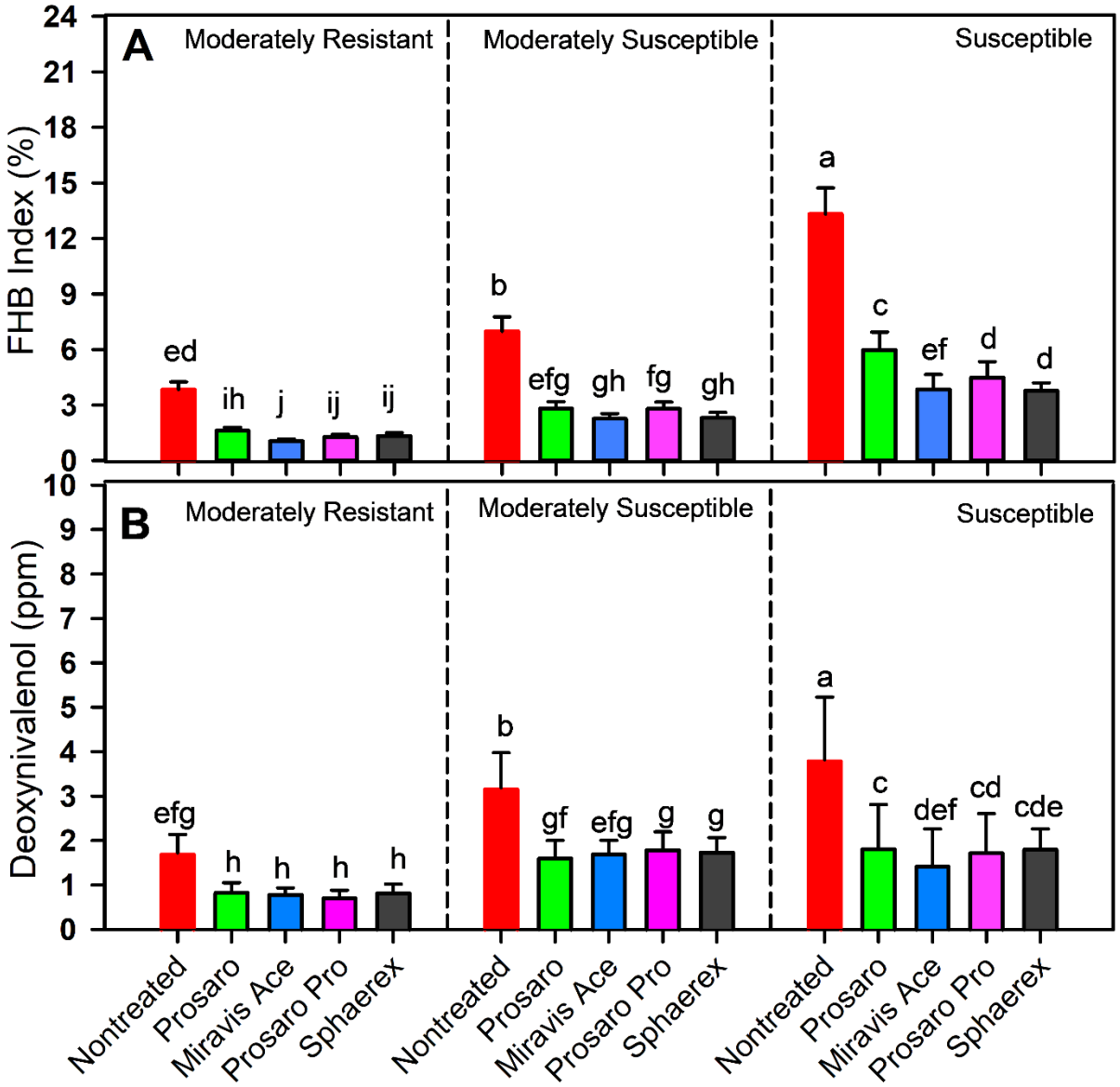

Fig. 2. Mean Fusarium head blight index (**A**), deoxynivalenol (DON) grain contamination (**B**) for different fungicide program x cultivar resistance management combinations. Cultivar resistance levels are indicated as susceptible, moderately susceptible, moderately resistant. The fungicide programs consisted of Prosaro at 6.5 fl. oz/acre, Miravis Ace at 13.7 fl. oz/acre, Prosaro Pro at 10.3 fl. oz/acre, and Sphaerex at 7.3 fl. oz/acre, all applied at anthesis, plus an nontreated check. Each bar represents the mean response averaged across trials and blocks from the 2022, 2023, and 2024 growing seasons. Error bars indicate the standard error of the mean. Statistical models were fitted, and means were compared on the arcsine square root-transformed scale for FHB index and the log-transformed scale for DON. Graphs are presented on the raw data scale for clarity.

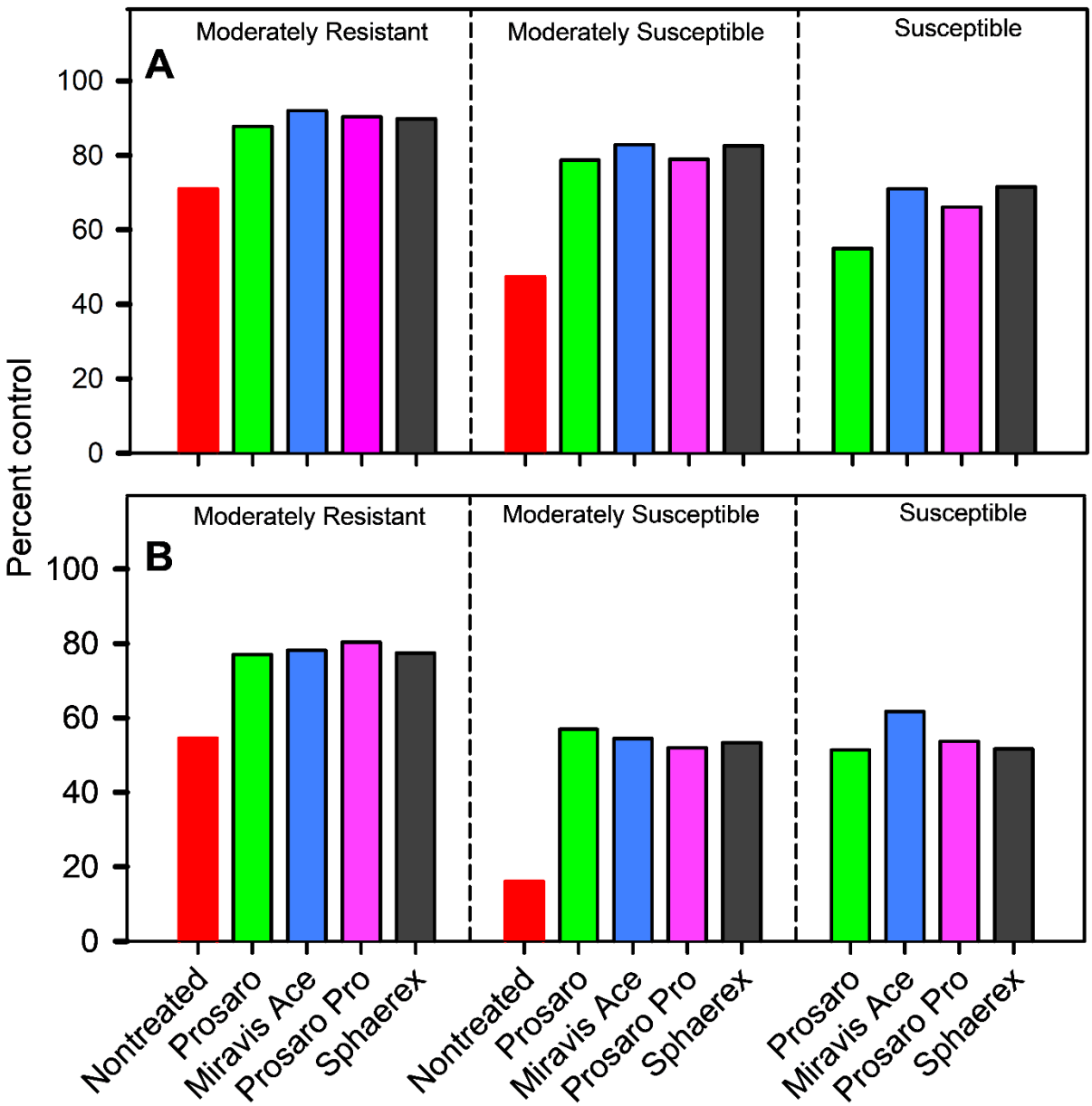

Fig. 3. Percent control of Fusarium head blight index (**A**) and deoxynivalenol contamination of grain (**B**) for management programs consisting of wheat cultivar resistance to FHB (Moderately Resistant, Moderately Susceptible, and Susceptible) by fungicide treatment combinations relative to the nontreated susceptible check. The fungicide programs consisted of Prosaro at 6.5 fl. oz/acre., Miravis Ace at 13.7 fl. oz/acre, Prosaro Pro, 10.3 fl. oz/acre, and Sphaerex, 7.3 fl. oz/acre, all applied at anthesis,