Fusarium Head Blight Management Coordinated Project: Integrated Management Trials 2022–2025

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

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Introduction: The integration of multiple strategies such as a timely fungicide application with genetic resistance is the most effective approach for reducing the impact of Fusarium head blight (FHB) and deoxynivalenol (DON) contamination on wheat grain yield and quality. As new fungicides such as Prosaro Pro, Miravis Ace, and Sphaerex become available on the market and new FHB resistant varieties are released, studies such as this are necessary to (re)evaluate the efficacy, cost, and benefit of integrating multiple strategies for managing this disease-toxin complex across a range of environments and grain market classes. Questions have arisen about whether newly registered fungicides such as 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 2022–2025 growing seasons was to evaluate whether Prosaro Pro and Sphaerex are as effective as Prosaro and Miravis Ace in controlling FHB and DON, either alone or within integrated management programs.

Materials and Methods: During the 2022–2025 growing seasons, field experiments were conducted across 20 U.S. wheat-producing states. The experiments followed a standard protocol in which 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). Treatment–cultivar combinations 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 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, with cultivar resistance as whole the plot and fungicide treatment as sub-plot. Each trial included 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 anthers extruded in the center of the spikes

Results and Discussion:

Distributions of (FHB) index and DON: Figure 1. illustrates the distribution of mean IND and DON for treatment combinations across environments (location x years). These environments represented spring- and winter wheat-growing regions, spanning five wheat market classes: durum, hard red spring, soft red spring, soft red winter, and soft white winter.

Least squares mean IND varied across environments and management combinations, ranging from 0 to 61% (**Fig. 1A**). Similarly, least squares mean DON concentration in grain ranged from 0 to 28 ppm across environments and management combinations (**Fig.1B**). Among nontreated checks, the moderately resistant check (MR_CK) exhibited a relatively narrow interquartile range (IQR) of 3.8% for IND, with 50% of the values falling between 0.3 to 4.1%. In contrast, the susceptible nontreated check (S_CK) had a wider IQR range of 14.1% and the highest mean IND (10.9%), with half of the values falling between 0.6 to 14.6%.
A similar trend was observed for the DON concentration pattern among nontreated checks, with the MR_CK showing the narrowest IQR (2.2 ppm), followed by the moderately susceptible check (4.8 ppm). S_CK exhibited the widest IQR for DON (4.9 ppm) and a mean of 4.2 ppm, with half of the values falling between 0.3 to 5.2 ppm.

Fusarium head blight (FHB) index: All integrated treatment combinations had significantly lower mean IND than the susceptible check (S_CK; 10.9%) (Fig 2). Treatment combinations involving the application of Prosaro, Miravis Ace, Prosaro Pro, or Sphaerex at anthesis to moderately resistant (MR) cultivars resulted in lowest mean IND values (Fig. 2A). Mean IND did not differ significantly among fungicide treatments when applied at anthesis to MR or MS cultivars ($P > 0.05$). However, when applied to susceptible (S) cultivars, Miravis Ace resulted in significantly lower ($P < 0.05$) mean IND than Prosaro, Sphaerex, and Prosaro Pro.

Deoxynivalenol (DON): Within each resistance class, all fungicide treatments resulted in significantly lower mean DON contamination than the nontreated check ($P < 0.001$). The susceptible nontreated check (S_CK) exhibited the highest mean DON contamination (4.2 ppm), and the widest interquartile range (IQR = 4.9 ppm). As observed for IND, the lowest mean DON levels occurred when Prosaro, Miravis Ace, Prosaro Pro, or Sphaerex were applied at anthesis to MR cultivars, with means values ranging between 0.9 to 1.2 ppm. Among the nontreated checks, S_CK had the highest mean DON concentration, whereas the MR_CK had the lowest (0.9 ppm) (**Fig. 2B**). Mean DON concentrations did not differ significantly among fungicide treatments when applied to MR, MS, or S cultivars.

Efficacy of FHB management programs against IND and DON contamination of grain: Relative to nontreated check, the integrated management programs combining one of the tested fungicides with a moderately resistant cultivar provided the greatest efficacy against IND and DON contamination, with 82–88% control of IND and 71–78% control of DON (Fig. 3). Programs involving a moderately susceptible cultivar treated with a fungicide showed intermediate efficacy, with 72–76% reduction in mean IND and 52–61% reduction in mean DON (Fig. 3). The least effective programs were those consisting of susceptible cultivars treated with fungicides, which provided 55–72% control of IND and 50–59% control of DON (Fig. 3).

When fungicide-only management programs were evaluated, i.e. fungicide treatments applied to susceptible cultivars, Miravis Ace, Sphaerex, and Prosaro Pro provided greater control of IND than Prosaro, the industry standard. Relative to Prosaro, Miravis Ace, Sphaerex, and Prosaro Pro reduced IND by 38%, 19%, and 17%, respectively. In contrast, trends differed for DON contamination: Miravis Ace reduced DON by approximately 16% relative to Prosaro, whereas Sphaerex achieved only a 3% reduction. Prosaro pro was slightly less effective for DON, with efficacy 2% lower than that of Prosaro.

Based on the pooled data from 2022–2025 growing seasons, the newly released fungicides Prosaro Pro and Sphaerex were as effective as the industry-standard Prosaro in reducing IND and DON when applied to moderately resistant or moderately susceptible cultivars within integrated management programs. In contrast, when applied to susceptible cultivars, Prosaro Pro and Sphaerex provided greater control of IND (based on percent reduction) than Prosaro, while exhibiting comparable efficacy for DON. The experiments will be repeated during the 2026 growing season, after which additional data will be pooled and analyzed to more fully quantify the effects of different management combinations.

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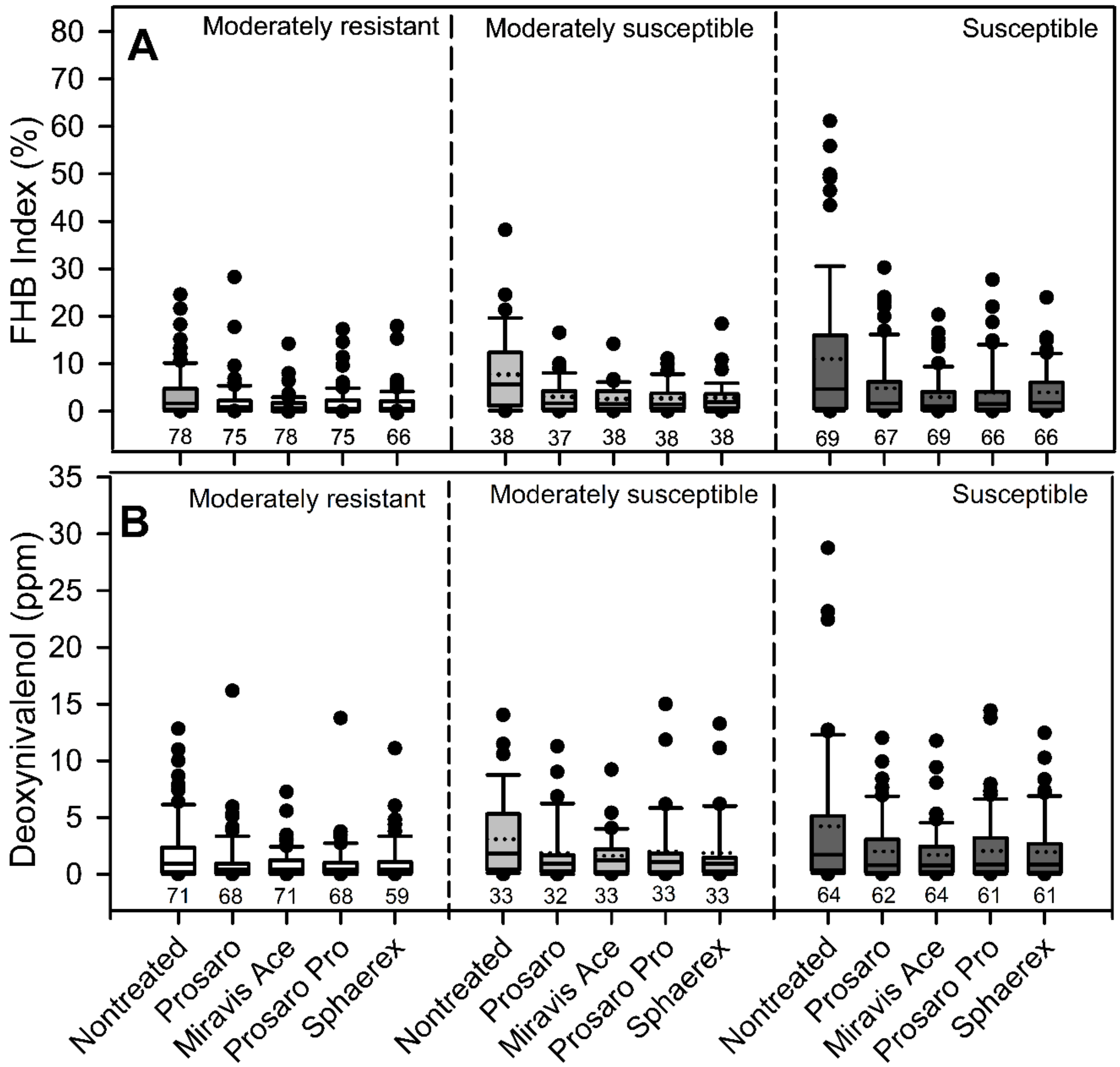

Fig. 1. Boxplots showing the distribution of least squares mean Fusarium head blight (FHB) index (%) (A) and deoxynivalenol (DON) grain contamination (ppm) (B) across fungicide program × cultivar resistance combinations. Cultivar resistance classes were susceptible, moderately susceptible, and moderately resistant. Fungicide programs included Prosaro (6.5 fl oz acre^{-1}), Miravis Ace (13.7 fl oz acre^{-1}), Prosaro Pro (10.3 fl oz acre^{-1}), and Sphaerex (7.3 fl oz acre^{-1}), each applied at anthesis, along with a nontreated check. Values represent combined least squares means across trials conducted from 2022 to 2025 growing seasons. Horizontal dashed lines indicate the overall mean FHB index or DON contamination. Numbers below the x-axis represent the number of trials contributing to each fungicide treatment was evaluated for the respective response variable.

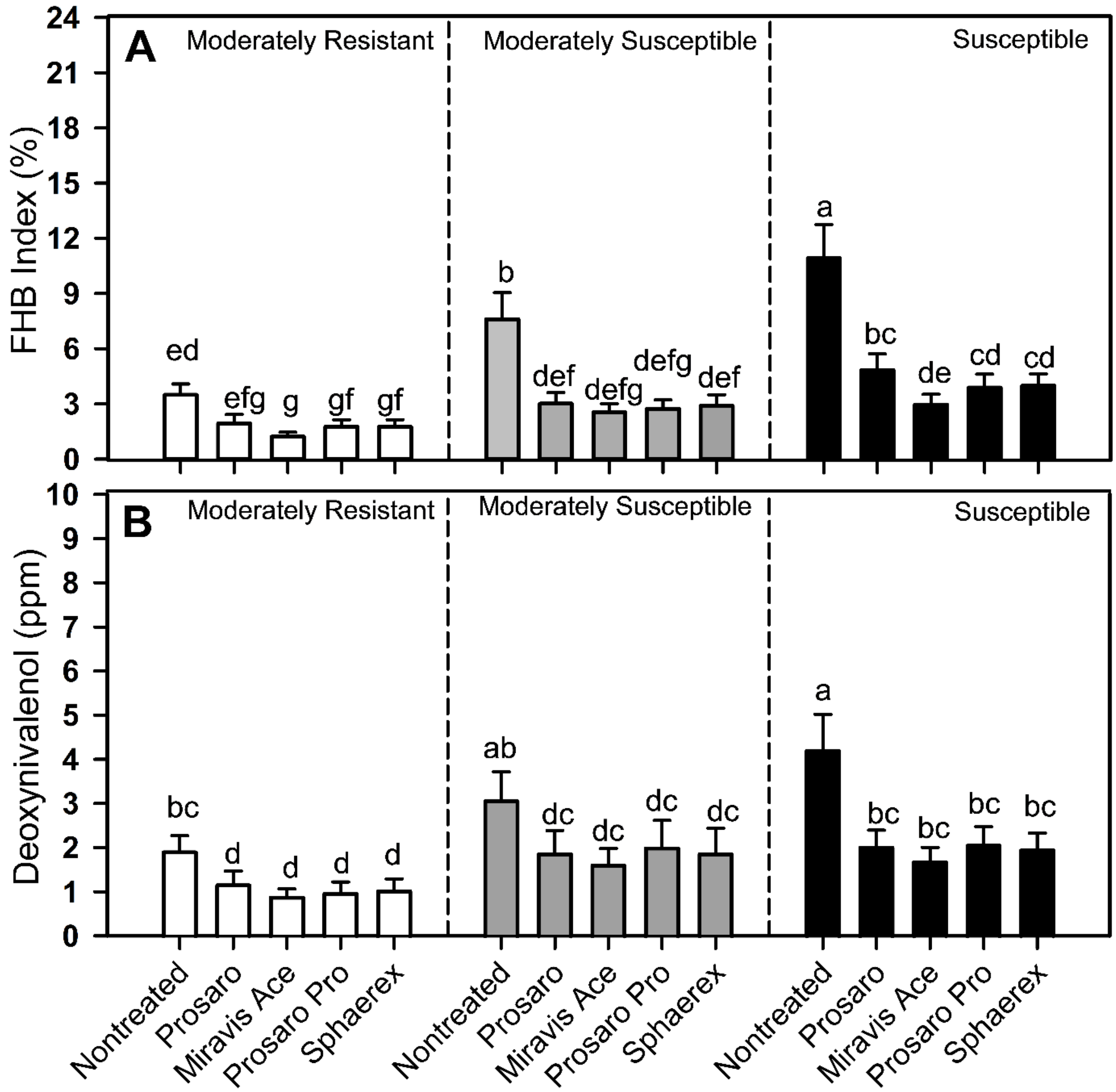

Fig. 2. Mean Fusarium head blight (FHB) index (%) (A) and deoxynivalenol (DON) grain contamination (ppm) (B) across fungicide program × cultivar resistance combinations. Cultivar resistance classes were susceptible, moderately susceptible, and moderately resistant. Fungicide programs consisted of Prosaro (6.5 fl oz acre^{-1}), Miravis Ace (13.7 fl oz acre^{-1}), Prosaro Pro (10.3 fl oz acre^{-1}), and Sphaerex (7.3 fl oz acre^{-1}), each applied at anthesis, along with a nontreated check. Bars represent mean averaged across trials conducted from 2022 to 2025 growing seasons, and error bars indicate the standard error of the mean. Different letters indicate significant differences among treatment means ($P \leq 0.05$). Statistical analyses were performed on arcsine square root–transformed FHB index values and log-transformed DON values; figures are presented on the raw data scale for clarity.

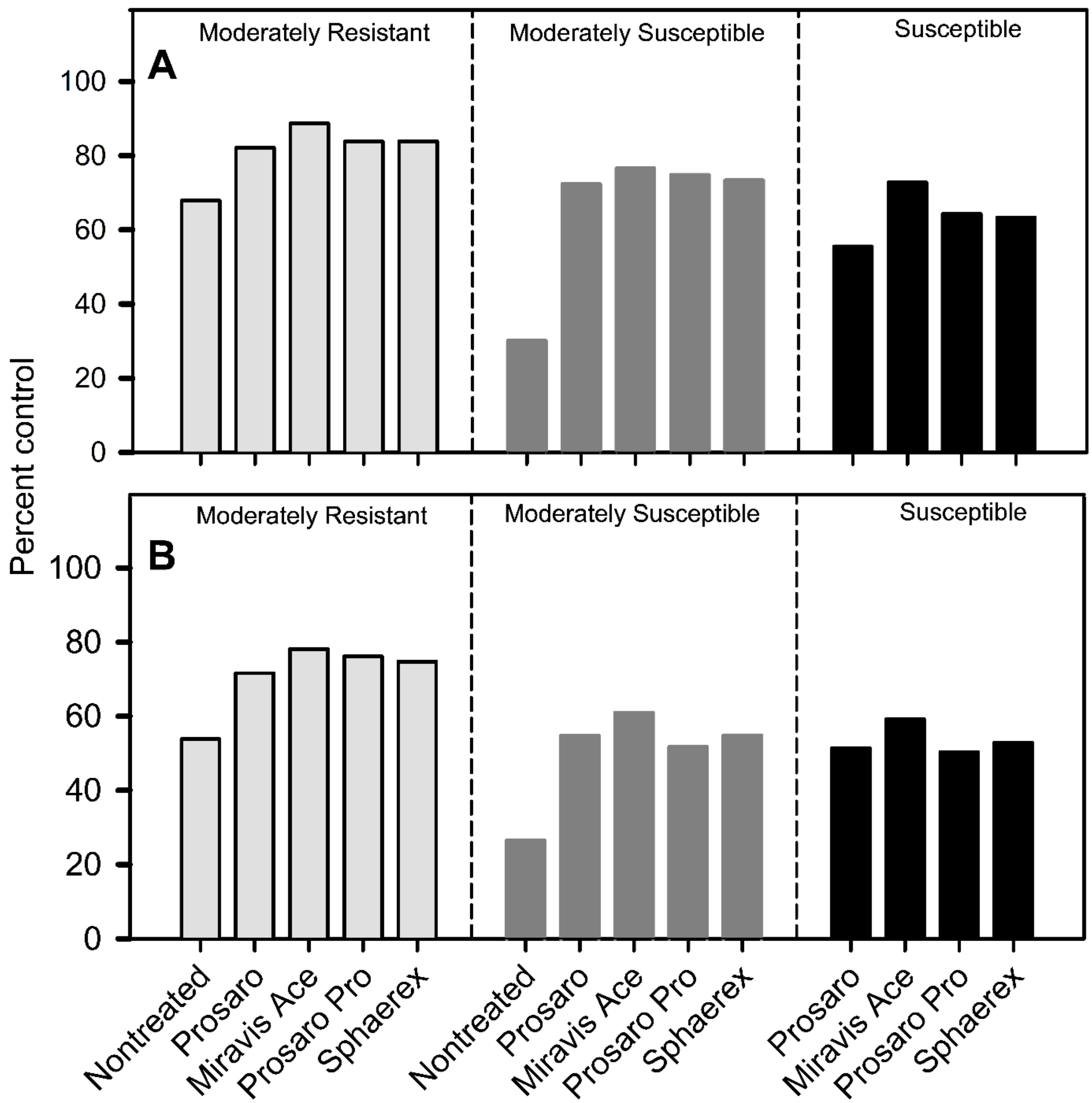

Fig. 3. Percent control of Fusarium head blight index (A) and deoxynivalenol contamination of grain (B) achieved by management programs consisting of wheat cultivar resistance to FHB (moderately resistant, moderately susceptible, and susceptible) combined with fungicide treatments, expressed relative to the nontreated susceptible check. Data represent combined results across trials conducted from 2022–2025 growing seasons. Fungicide programs included Prosaro (6.5 fl oz acre^{-1}), Miravis Ace (13.7 fl oz acre^{-1}), Prosaro Pro (10.3 fl oz acre^{-1}), and Sphaerex 7.3 fl oz acre^{-1}), each applied at anthesis.