

Fusarium Head Blight Management Coordinated Project: Uniform Fungicide Trials 2022–2025

Efficacy of new Fungicides for Fusarium head blight (FHB) and Deoxynivalenol (DON) management in wheat

Kikway Isaack¹, Bish D. Mandy², Bradley A. Carl³, Chilvers I. Martin⁴, Collins A. Alyssa⁵, Cowger Christina⁶, Darby Heather⁷, Esker D. Paul⁸, Friskop J. Andrew⁹, Higgins Douglas¹⁰, Kelly M. Heather¹¹, Koehler M. Alyssa¹², Marshall M. Juliet¹³, Mideros Santiago¹⁴, Onofre A. Kelsey¹⁵, Padget Guy¹⁶, Rawat Nidhi¹⁷, Shires K. Madalyn¹⁸, Smith L. Damon¹⁹, Telenko E. P. Darcy²⁰, Paul A. Pierce^{1*}

¹The Ohio State University, CFAES Wooster Campus, Wooster, OH 44691; ²University of Missouri, Columbia, MO 65211; ³University of Kentucky, Princeton, KY 42445; ⁴Michigan State University, East Lansing, MI 48824; ⁵The Pennsylvania State University, Manheim, PA 17545; ⁶North Carolina State University/USDA-ARS, Raleigh, NC 27695; ⁷The University of Tennessee at Knoxville, Jackson, TN 38301; ⁸The Pennsylvania State University, University Park, PA 16802; ⁹North Dakota State University, Fargo, ND 58102; ¹⁰Virginia Tech, Suffolk, VA 23437; ¹¹The University of Tennessee at Knoxville, Jackson, TN 38301; ¹²The University of Delaware, Georgetown, DE 19947; ¹³University of Idaho, Aberdeen, ID 83210; ¹⁴University of Illinois, Urbana, IL 61801; ¹⁵Kansas State University, Manhattan, KS 66506; ¹⁶Louisiana State University Ag Center, Baton Rouge, LA 70803; ¹⁷University of Maryland, College Park, MD 20742; ¹⁸South Dakota State University, Brookings, SD 57007; ¹⁹University of Wisconsin-Madison, Madison, WI 53706; ²⁰Purdue University, West Lafayette, IN 47907;

*Corresponding Author: PH: 330.263.3842; Email: paul.661@osu.edu

Introduction: Fusarium head blight (FHB) and associated grain contamination with mycotoxins such as deoxynivalenol (DON) continue to be of great economic importance in many wheat-producing regions of the United States. Prosaro has historically been one of the industry standards for FHB and DON management. However, newer fungicides such as Prosaro Pro®, Sphaerex®, and Miravis Ace® are now marketed for FHB and DON management, with efficacy, based on uniform fungicide trials (UFT), comparable to, or in some cases, greater than Prosaro. Successful management of FHB and DON depends on appropriate fungicide application timing, rate, and product selection. Newer fungicides such as Sphaerex® (metconazole + prothioconazole) and Prosaro Pro® (tebuconazole + prothioconazole + fluopyram), developed for FHB and DON suppression in wheat, are co-formulated products containing two or more active ingredients from the same and/or different fungicide mode-of-action groups. However, despite the introduction of these newer co-formulated fungicides, it remains unclear whether they provide equivalent or superior suppression of FHB and DON compared with established industry standards such as Prosaro®, Caramba®, and Miravis Ace®. Accordingly, a primary objective of the current round of FHB UFT coordinated projects is to evaluate and compare the efficacy of Prosaro Pro®, and Sphaerex® and A23751C (experimental fungicide; not yet registered for commercial use) with Prosaro®, Caramba®, and Miravis Ace® when applied to a susceptible wheat cultivar either at anthesis or as part of a two-treatment program involving an early anthesis application of Miravis Ace followed by a post-anthesis application of the other fungicides.

Materials and Methods: Field experiments were conducted during the 2022–2025 growing seasons under varying environmental conditions across 21 wheat-growing states in the United States. The experiments followed a standardized protocol in which the fungicide treatments outlined in Table 1 were applied to plots planted with a susceptible wheat cultivar. The trials were arranged in a randomized complete block design with a minimum of four replicate blocks. Artificial inoculation of the plots with *Fusarium graminearum* was performed using either colonized grain spawn or a spore suspension, applied approximately 24–36 hours after anthesis. In some trials, mist irrigation was used during and shortly after anthesis to promote inoculum production and infection. FHB index (IND) was estimated as mean percentage of diseased spikelets per spike (1), on 60–100 spikes per plot at approximately Feekes growth stage 11.2. Grain was harvested and samples were sent to a USWBSI-supported laboratory for mycotoxin analysis. Linear mixed models were fitted to arcsine square root-transformed IND data and log-transformed deoxynivalenol (DON) levels pooled across environments (trial × state × year combinations) to estimate treatment effects and compare means. Overall fungicide efficacy was estimated as percent reduction in mean IND and DON relative to the nontreated control.

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

Treatment	Product	Rate/Acre (fl oz)	Timing*
CK	Nontreated check
I	Prosaro	6.5	Feekes 10.5.1 (early anthesis)
II	Caramba	13.5	Feekes 10.5.1 (early anthesis)
III	Miravis Ace	13.7	Feekes 10.5.1 (early anthesis)
IV	Prosaro Pro	10.3	Feekes 10.5.1 (early anthesis)
V	Sphaerex	7.3	Feekes 10.5.1 (early anthesis)
VI	Miravis Ace fb Prosaro Pro	13.7 fb 10.3	Early anthesis/4–6 DAA
VII	Miravis Ace fb Sphaerex	13.7 fb 7.3	Early anthesis/4–6 DAA
VIII	Miravis Ace fb Tebuconazole	13.7 fb 4	Early anthesis/4–6 DAA
M-ERA	A23751C	10.2	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. DAA = days after anthesis.

Results and Discussion:

Distributions of FHB IND and DON: The distributions of least squares mean IND and DON contamination across environments (locations and growing seasons) for the different fungicide programs are presented in Figures 1A and 1B, respectively. Across all location-years, the nontreated check exhibited a mean IND of 0 to 50.2% and DON concentrations of 0 to 40.6 ppm. Among single-application fungicide programs, the standard anthesis-only application of Miravis Ace had the lowest mean values, with 50% of the values falling between 0.6 to 5.9% IND (Fig. 1A) and between 0.2 to 3.1 ppm for DON (Fig. 1 B). Two-treatment programs consisting of Miravis Ace applied at anthesis followed by Prosaro Pro or Sphaerex 4–6 days after anthesis resulted in the lowest mean FHB index (IND) and DON levels among all programs evaluated. For these sequential treatments, 50% of observations ranged from 0.3 to 4.4% (Prosaro Pro) and 0.3 to 4.1% (Sphaerex) for IND, and from 0.1 to 2.3 ppm and 0.1 to 2.2 ppm for DON, respectively. In contrast, mean IND for A23751C, a new fungicide under evaluation, ranged from 0 to 57%, while DON levels ranged from 0 to 31.5 ppm.

Fusarium head blight FHB IND: Compared with the nontreated check, all fungicide programs significantly reduced mean IND on the arcsine square root-transformed scale ($P < 0.001$; Fig. 2A). Among single-application programs, an anthesis application of Miravis Ace resulted in significantly lower mean IND than single anthesis application of Prosaro, Caramba, Prosaro Pro, or Sphaerex ($P < 0.001$; Fig. 2A). In contrast, single anthesis application of A23751C produced mean IND values comparable to those of Prosaro, Caramba, Miravis Ace, Prosaro Pro, and Sphaerex applied at anthesis. Two application programs consisting of Miravis Ace applied at anthesis followed by post-anthesis application of Prosaro Pro or Sphaerex resulted in the lowest mean IND values and were significantly more effective than all other treatments evaluated ($P < 0.001$; Fig. 2A).

Deoxynivalenol (DON): Relative to the nontreated check, all fungicide programs significantly reduced mean DON contamination of grain on the log-transformed scale ($P < 0.001$; Fig. 2B). Among single-application programs, Miravis Ace applied at anthesis produced mean DON values comparable to those of the other anthesis-only treatments (Fig. 2B). The experimental fungicide A23751C, applied at anthesis, produced mean DON values comparable to those of Prosaro, Caramba, Miravis Ace, Prosaro Pro, and Sphaerex. Two-applications programs consisting of Miravis Ace at anthesis followed by Prosaro Pro or Sphaerex 4 to 6 days later achieved the lowest mean DON contamination and were significantly more effective than all other fungicide programs evaluated ($P < 0.001$; Fig. 2B).

Overall efficacy of FHB fungicide programs against IND and DON contamination of grain: The efficacy of the tested fungicide programs against IND and DON contamination of grain relative to the nontreated check varied considerably, with percentage control (C) ranging from 49 to 75% for IND and 31 to 60% for DON. Among the single-application programs, Miravis Ace provided the highest percentage reduction of IND (C = 66%) IND. Relative to the industry standard Prosaro applied at anthesis, Miravis Ace reduced mean IND by 31%. Except for Caramba, which was the least effective single-application treatment relative to Prosaro, other single-application treatments (Prosaro Pro, Sphaerex,) exhibited comparable efficacy, with percentage control values for IND ranging from 2 to 4% (Fig. 3A). In contrast, the new fungicide A23751C showed the lowest efficacy for IND among all the treatments relative to Prosaro.

Sequential applications of Miravis Ace at anthesis followed by a late application (4 to 6 days after anthesis) of either Prosaro Pro or Sphaerex were the most effective of all tested fungicide programs. The efficacy of the tested fungicide programs for DON suppression varied among treatments with percent control relative to nontreated check ranging between 31 to 60% for DON. Among the single-application programs, Miravis Ace provided the highest percentage reduction of DON (C = 44%) (Fig 3A and 3B). Compared with the industry standard Prosaro applied at anthesis, Miravis Ace reduced mean DON by 17%, respectively. For DON, the new fungicide A23751C showed the lowest efficacy (C = 30% relative to the nontreated check) and was slightly less effective than Prosaro by 2%.

Sequential applications of Miravis Ace at anthesis followed by a late application (4 to 6 days after anthesis) of either Prosaro Pro or Sphaerex were the most effective of all tested fungicide programs. These two-application programs resulted in approximately 24 to 29% reductions in IND and DON relative to Miravis Ace applied alone at anthesis.

The findings from this four-year study indicate that Miravis Ace at anthesis was the most effective of the tested anthesis-only treatments and that the newly registered fungicides Prosaro Pro and Sphaerex at Feekes 10.5.1 generally were of comparable efficacy to Prosaro. Sequential fungicide application programs were generally more effective at reducing FHB index (IND) and DON levels

than single applications at anthesis. For example, programs applying Miravis Ace at anthesis followed by a later application of Prosaro Pro or Sphaerex provided greater control of FHB and DON than any single anthesis application of the tested fungicides. Preliminary results from the 2024 and 2025 growing seasons indicated that A23751C, an experimental fungicide not yet registered for FHB and DON management, performed comparably to Prosaro, the industry standard, as well as to Prosaro Pro and Sphaerex, two recently introduced fungicides. These experiments will be repeated, and the resulting data will be analyzed to quantitatively assess efficacy and evaluate the additive effects of active ingredient mixtures and sequential fungicide applications.

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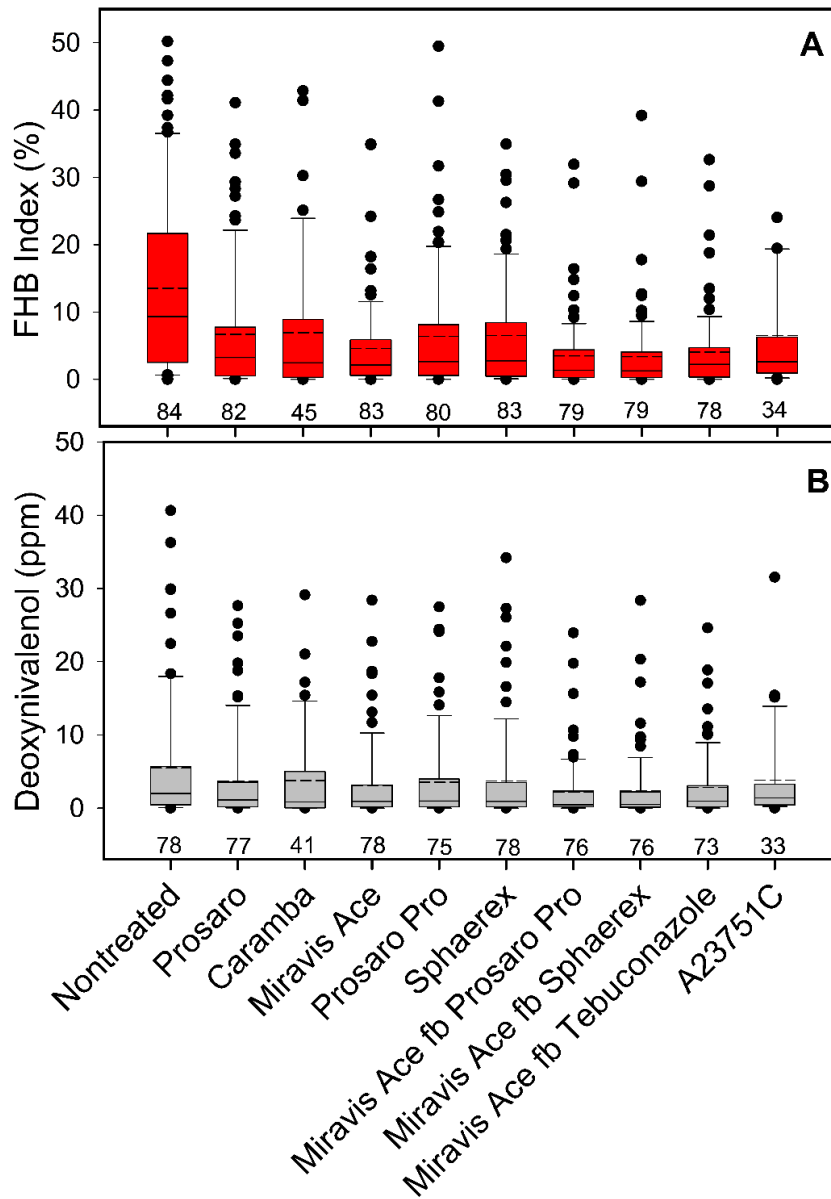


Fig. 1. Boxplots showing the distribution of least square mean Fusarium head blight (FHB) index (%) (A) and deoxynivalenol (DON) grain contamination (ppm) (B) for fungicide treatments and a nontreated check across trials conducted from 2022-2025 growing seasons. All fungicide treatments included a nonionic surfactant at 0.125% (vol/vol). Single-application treatments were applied at Feekes 10.5.1 (early anthesis; approximately 50% of tillers with fresh anthers extruded in the center of spikes) and included: Prosaro (6.5 fl oz acre⁻¹), Caramba (13.5 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); and A23751C (10.2 fl oz acre⁻¹), evaluated in 2024 and 2025 only. Sequential programs consisted of Miravis Ace (13.7 fl oz acre⁻¹) applied at early anthesis followed by Prosaro Pro (10.3 fl oz acre⁻¹), Sphaerex (7.3 fl oz acre⁻¹), or tebuconazole (4 fl oz acre⁻¹) applied 4–6 days after anthesis. Boxplots represent the distribution of least square means across trials. Horizontal dashed lines indicate the overall mean FHB index (A) or DON concentration (B). Numbers above the x-axis denote the number of trials in which each fungicide treatment was evaluated for the respective response variable.

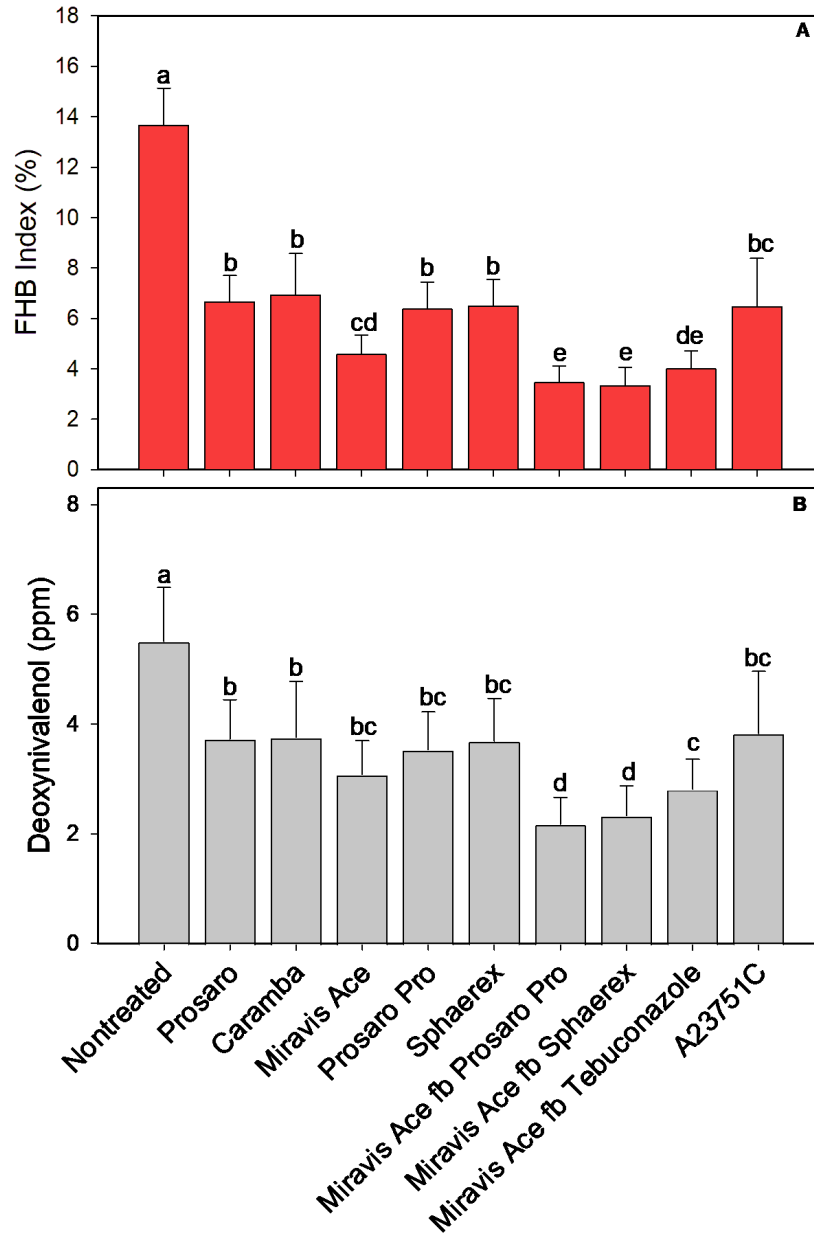


Fig 2. Mean Fusarium head blight index (%) (A) and deoxynivalenol (DON) grain contamination (ppm) (B) for fungicide treatments and nontreated check across trials conducted from 2022-2025. All fungicide treatments included a nonionic surfactant at 0.125% (vol/vol). Single-application treatments were applied at Feekes 10.5.1 (early anthesis; approximately 50% of tillers with fresh anthers extruded in the center of spikes) and included: Prosaro (6.5 fl oz acre⁻¹), Caramba (13.5 fl oz acre⁻¹), Miravis Ace (13.7 fl oz acre⁻¹), Prosaro Pro (10.3 fl oz acre⁻¹), Sphaerex (7.3 fl oz acre⁻¹), and A23751C (10.2 fl oz acre⁻¹), with A23751C evaluated in 2024 and 2025 only. Sequential fungicide programs consisted of Miravis Ace (13.7 fl oz acre⁻¹) applied at early anthesis, followed by Prosaro Pro (10.3 fl oz acre⁻¹), Sphaerex (7.3 fl oz acre⁻¹), or tebuconazole (4 fl oz acre⁻¹) applied 4–6 days after anthesis. Bars represent treatment means, and error bars indicate the standard error of the mean. Different letters indicate significant differences among treatments ($P \leq 0.05$). Statistical analyses were conducted with fungicide treatment as a fixed effect; FHB index and DON concentrations were analyzed using arcsine square root and log transformations, respectively. Means are presented on the original (untransformed) scale for clarity.

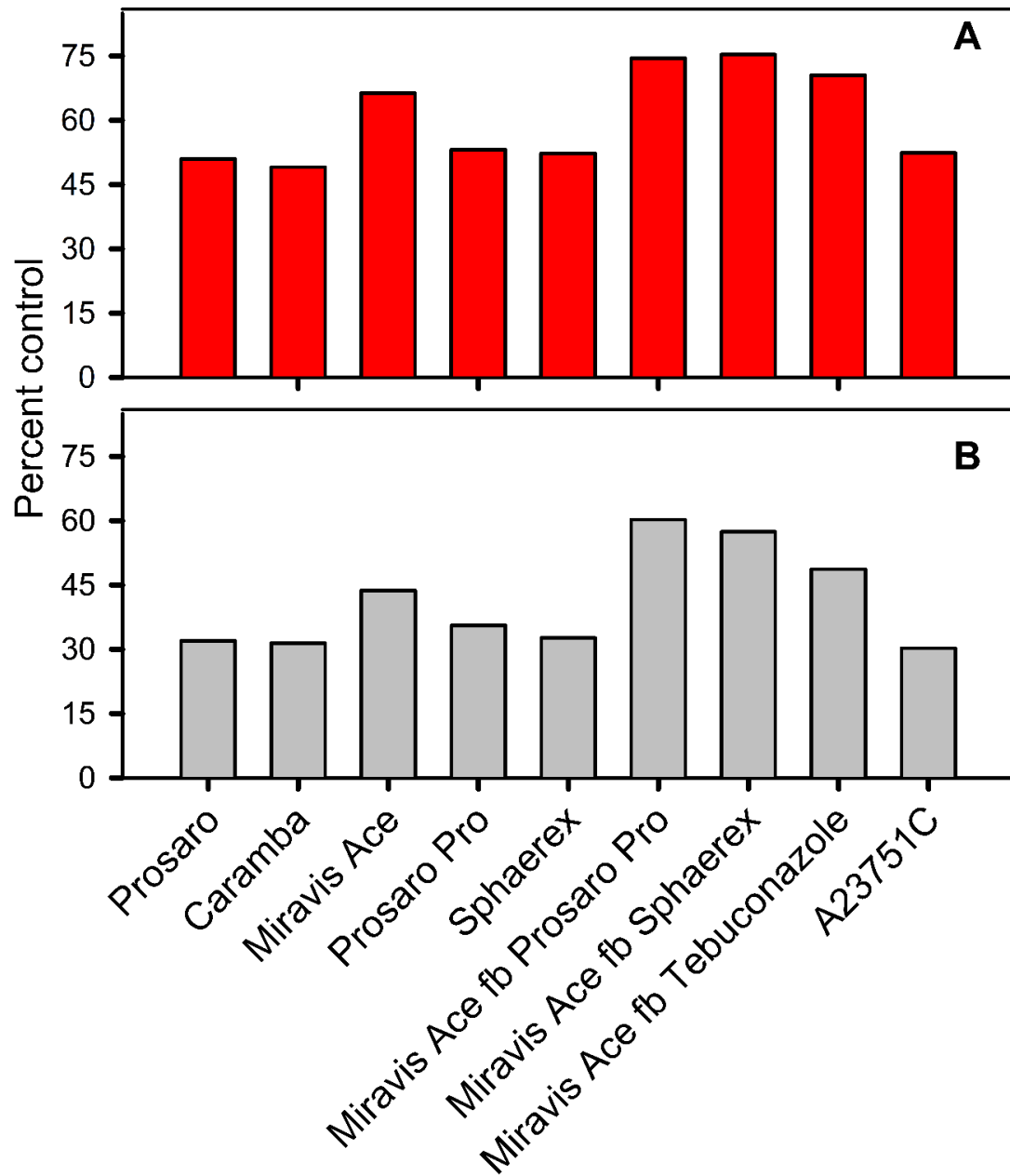


Fig. 3. Percent reduction in Fusarium head blight (FHB) index (%) (A) and deoxynivalenol (DON) grain contamination (ppm) (B) relative to the nontreated control for fungicide treatments across trials conducted from 2022 to 2025. All fungicide treatments included a nonionic surfactant at 0.125% (vol/vol). Single-application treatments were applied at Feekes 10.5.1 (early anthesis; approximately 50% of tillers with fresh anthers extruded from the center of spikes) and included Prosaro (6.5 fl oz acre⁻¹), Caramba (13.5 fl oz acre⁻¹), Miravis Ace (13.7 fl oz acre⁻¹), Prosaro Pro (10.3 fl oz acre⁻¹), Sphaerex (7.3 fl oz acre⁻¹), and A23751C (10.2 fl oz acre⁻¹), with A23751C evaluated in 2024 and 2025 only. Sequential fungicide programs consisted of Miravis Ace (13.7 fl oz acre⁻¹) applied at early anthesis, followed by Prosaro Pro (10.3 fl oz acre⁻¹), Sphaerex (7.3 fl oz acre⁻¹), or tebuconazole (4 fl oz acre⁻¹) applied 4–6 days after anthesis. Bars represent mean percent reduction relative to the nontreated control for each response variable, calculated using model-derived least squares means.