Fusarium Head Blight Management Coordinated Project: Uniform Fungicide Trials for 2022 and 2023

Comparative assessment of two new fungicides against Fusarium head blight (FHB) and Deoxynivalenol (DON) management in wheat

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Introduction: Fungicides are essential for Fusarium head blight (FHB) and deoxynivalenol (DON) management in small grain crops. However, for successful FHB and DON management, fungicide application timing, rate, and product are all important. Two new fungicide mixtures, Sphaerex® (metconazole + prothioconazole) and Prosaro Pro® (tebuconazole + prothioconazole + Fluopyram), are currently being marketed for use in wheat for FHB and DON management. However, it is unclear whether these new fungicides are just as consistently effective as or more effective than the current industry standards Prosaro, Caramba, and Miravis Ace against FHB and DON. With emphasis on these newly registered fungicides, the objective of the FHB Uniform Fungicide coordinated project during the 2022 and 2023 growing seasons was to compare the efficacy of Prosaro Pro (a premix of the DMIs tebuconazole and prothioconazole and the SDHI Fluopyram) and Sphaerex (a premix of metconazole and prothioconazole) to that of Prosaro, Caramba, and Miravis Ace, industry standards for FHB and DON management, when applied to a susceptible cultivar at anthesis or when applied after anthesis as part of two-treatment programs consisting of an anthesis application of Miravis Ace.

Materials and Methods: Field experiments were conducted under different environmental conditions in 24 US wheat-growing states in 2022 and 2023 growing seasons. The standard protocol consisted of the application of the different fungicide treatments in **Table 1** to plots of a susceptible wheat cultivar. The experimental design was a randomized complete block, with at least 4 replicate blocks. In all experiments, plots were artificially inoculated with either *Fusarium graminearum*-

colonized grain spawn or a spore suspension of the fungus applied approximately 24-36 hours after anthesis. Plots were mist-irrigated during and shortly after anthesis in some experiments to enhance inoculum production and infection. To ascertain disease intensity during the study, FHB index (IND) was rated or calculated as previously described (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. To evaluate treatment effects, linear mixed models (multi-location) were fitted to arcsine square root-transformed IND and log-transformed DON data pooled across environments (trial x state x year combinations). Percent reduction in IND and DON relative to the nontreated check was used to estimate efficacy of fungicide.

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	Untreated 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	13.7/10.3	Early anthesis/4-6 DAA
VII	Miravis Ace fb Sphaerex	13.7/7.3	Early anthesis/4-6 DAA
VIII	Miravis Ace fb Tebuconazole	13.7/4	Early anthesis/4-6 DAA

*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: The distributions of mean Fusarium head blight index (IND) and deoxynivalenol (DON) contamination across 31 environments (21 in 2022 and 10 in 2023) are shown for different fungicide programs in Figures 1A and 1B, respectively. Across the 31 environments, IND ranged from 0 to 50 % and DON from 0 to 62 ppm. The standard anthesis-only application of Miravis Ace had the lowest means of all single-treatment fungicide application programs, with 50% of the values below 3.7 % for IND **(Fig. 1A)** and below 1.4 ppm for DON (**Fig. 1 B**). However, two-treatment programs consisting of sequential application of Miravis Ace at anthesis followed by Prosaro Pro (VI) or Sphaerex (VII) at 4 to 6 days after anthesis resulted in the lowest means of all tested treatments, with 50% of the values below 1.2 % for IND and below 1.0 ppm for DON.

FHB index: Compared to the nontreated check, all tested fungicide programs resulted in significantly lower mean IND (on the arcsine square root-transformed scale) (**Fig. 2A**). A single application of Miravis Ace at anthesis (III) resulted in significantly lower mean IND compared to a single application of Prosaro (I), Caramba (II), Prosaro Pro (IV), or Sphaerex (V) at anthesis (**Fig. 2A**). Compared to Caramba alone at anthesis, all tested fungicide programs, including Sphaerex alone at anthesis, resulted in significantly lower mean IND. An anthesis application of Miravis Ace followed by a late application of Prosaro Pro (VI) or Sphaerex (VII) (**Fig. 2A)** resulted the lowest mean IND of all tested treatments. Both programs had significantly lower means (on the arcsine square root-transformed scale) than all single-treatment programs (I, II, III, IV, and V) (**Fig. 2A**).

Deoxynivalenol: Relative to the nontreated check, all tested fungicide programs resulted in significantly lower mean DON contamination of grain (on the log-transformed scale) (**Fig. 2B**).

Compared to other single-treatment fungicide application programs (I, II, and V), except for Prosaro Pro (IV), Miravis Ace resulted in significantly lower mean DON, (**Fig. 2B**). Compared to Caramba alone at anthesis, all tested fungicide programs, including Sphaerex alone at anthesis, resulted in significantly lower mean DON. Of all tested programs, sequential applications of Miravis Ace at anthesis followed by Prosaro Pro or Sphaerex 4 to 6 days later (VI and VII, respectively) showed significantly lower mean DON contamination of grain than all single-treatment fungicide application programs (I, II, II, IV, V) (**Fig. 2B**).

Efficacy of FHB management treatments against IND and DON contamination of grain: Relative to the nontreated check, percent control (C) across fungicide programs ranged from 35 to 85% for IND and 22 to 66% for DON. Miravis Ace resulted in the highest percent reduction in mean IND (C = 75%) and DON (C = 52%) among programs that consisted of a single application at anthesis. Efficacy was comparable among other single-treatment programs, with percent control values between 55 and 59% for IND and between 41 and 46% for DON. Relative to the standard application of Prosaro at anthesis, percent reduction in IND and DON for Miravis Ace was 47 and 20%, respectively. Sequential applications of Miravis Ace at anthesis followed by a late application (4 to 6 DAA) of Prosaro Pro (VI) or Sphaerex (VII) were considerably more effective against IND and DON than Miravis Ace only at anthesis, with about 10 and 10-14% reduction in IND and DON, respectively, relative to Miravis Ace applied alone at anthesis.

The results summarized in this two-year study suggest that an application of newly registered fungicides Prosaro Pro or Sphaerex at Feekes 10.5.1 was generally of comparable efficacy to Prosaro. Additionally, the tested programs consisting of sequential application of fungicides was generally more effective for FHB index and DON management than a single application at anthesis. For instance, programs with an anthesis application of Miravis Ace followed by a "later" application of Prosaro Pro or Sphaerex were more effective against IND and DON than an anthesis-only application of any of the tested fungicides. The experiments will be repeated, and all data will be analyzed to formally quantify efficacy and determine the additivity of active ingredient mixtures and sequentially applied fungicide treatments.

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References:

1. Paul, P. A., El-Allaf, S. M., Lipps, P. E., and Madden, L. V. 2005. Relationships between incidence and severity of Fusarium head blight on winter wheat in Ohio. Phytopathology 95:1049-1060.

2. Paul, P. A., Lipps, P. E., Hershman, D. E., McMullen, M. P., Draper, M. A., and Madden, L. V. 2008. Efficacy of triazole-based fungicides for Fusarium head blight and deoxynivalenol control in wheat: A multivariate meta-analysis. Phytopathology 98:999-1011.
3. Salgado et al. 2018. Efficacy of Miravis Ace for FHB and DON management across environments and grain market classes: A progress report. In: Canty, S., A. Hoffstetter, B. Wiermer and R. Dill-Macky (Eds.), Proceedings of the 2018 National Fusarium Head Blight Forum (p. 40-44). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

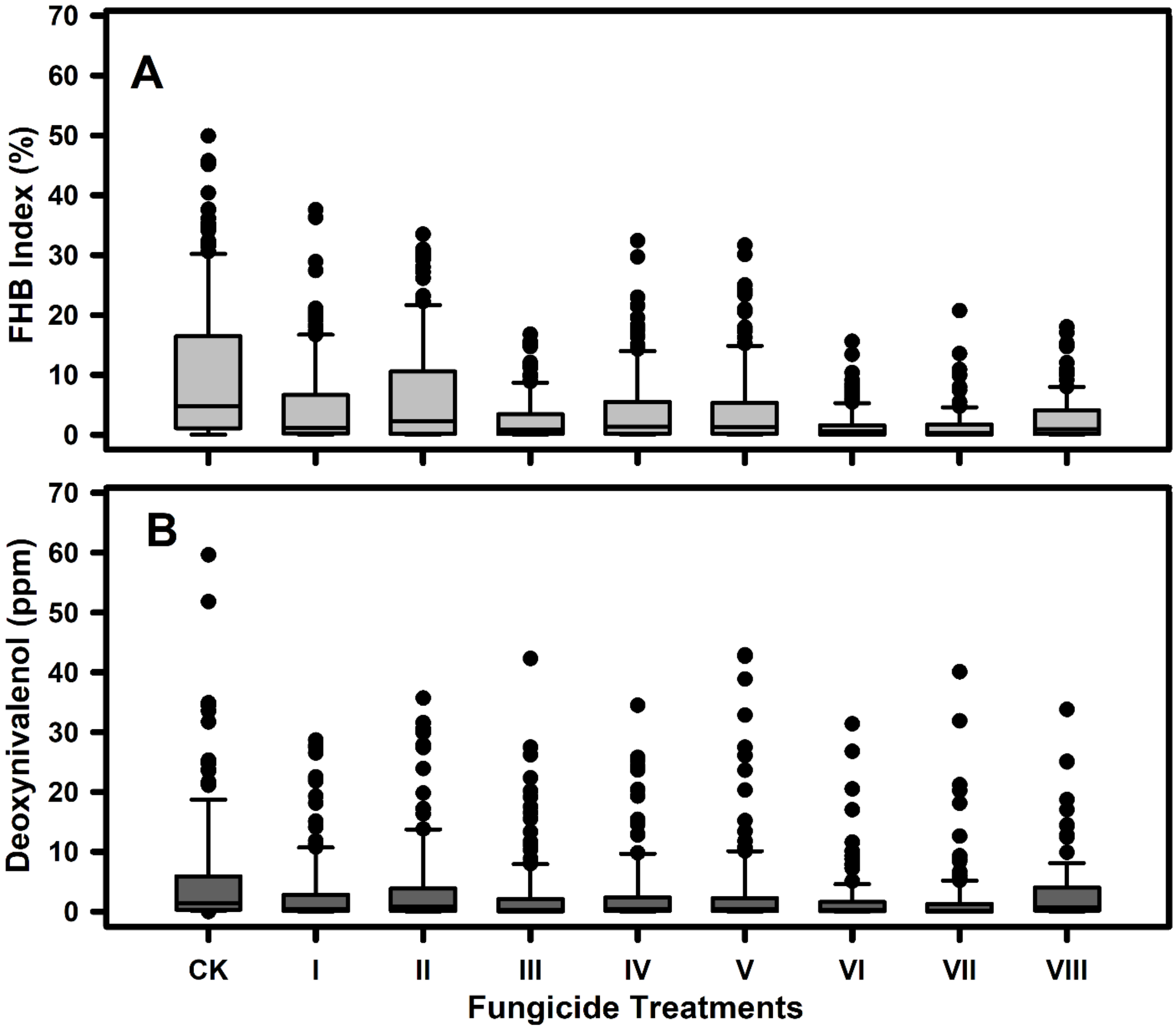

Fig. 1. Boxplots showing the distribution of **A**, mean Fusarium head blight index and **B**, deoxynivalenol grain contamination for different fungicide treatments. **CK** = nontreated check, **I** = Prosaro (6.5 fl. oz.) applied at anthesis, **II** = Caramba (13.5 fl. oz.) applied at anthesis, **III** = Miravis Ace (13.7 fl. oz.) applied at anthesis, **IV** = Prosaro Pro (10.3 fl. oz.) applied at anthesis, **V** = Sphaerex (7.3 fl. oz.) applied at anthesis, **VI** = Miravis Ace applied at anthesis followed by Prosaro Pro 4-6 days later, **VII** = Miravis Ace applied at anthesis followed by Sphaerex 4-6 days later, and **VIII** = Miravis Ace applied at anthesis followed by Tebuconazole (4 fl. oz) 4-6 days later. For FHB index, each box in **A** represents data points across 31 trials, whereas for DON, each box in **B** represents data points across x trials in 2022 and 2023 growing seasons.

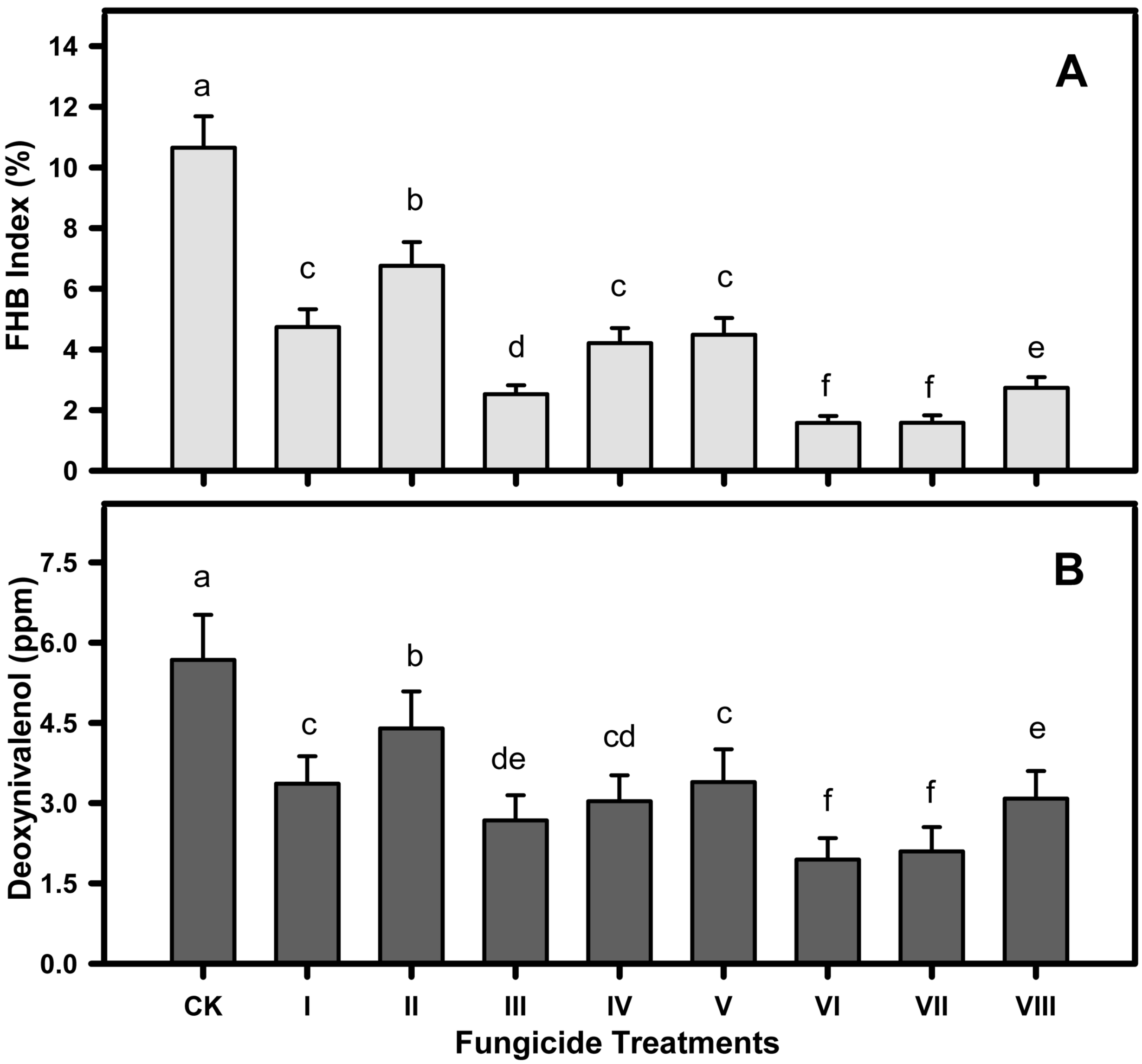

Fig 2. Mean **A**, Fusarium head blight index and **B**, deoxynivalenol grain contamination for different fungicide treatments for trials conducted in 2022 and 2023 growing season in different environments. **CK** = nontreated check, **I** = Prosaro (6.5 fl. oz.) applied at anthesis, **II** = Caramba (13.5 fl. oz.) applied at anthesis, **III** = Miravis Ace (13.7 fl. oz.) applied at anthesis, **IV** = Prosaro Pro (10.3 fl. oz.) applied at anthesis, **V** = Sphaerex (7.3 fl. oz.) applied at anthesis, **VI** = Miravis Ace applied at anthesis followed by Prosaro Pro 4-6 days later, **VII** = Miravis Ace applied at anthesis followed by Sphaerex 4-6 days later, and **VIII** = Miravis Ace applied at anthesis followed by Tebuconazole (4 fl. oz) 4-6 days later. For FHB index, each bar in **A** represents the mean across 21 trials, whereas for DON, each bar in **B** represents the mean across 20 trials. Errors bars are standard errors of the mean. Models were fitted and means were compared on the arcsine square root-transformed scale for IND and log-transformed sale for DON, with fungicide treatments as a fixed effect. Graphs are shown on the raw data scale for convenience.