Fusarium Head Blight Management Coordinated Project: Uniform Fungicide Trials 2018-2021

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Introduction: Uniform fungicide trials (UFT) were conducted over the last years (2018, 2019, 2020, and 2021) to compare the efficacy of Miravis Ace®, a new Succinate Dehydrogenase Inhibitor (SDHI; Adepidyn/Pydiflumetofen) + Demethylation Inhibitor (DMI; Propiconazole) fungicide, when applied at, before, or after anthesis, or sequentially with a DMI fungicide to that of a standard anthesis-only application of Prosaro® or Caramba®. Miravis Ace was recently labeled for management of diseases of wheat, barley, and other small grain crops, and preliminary results from a limited number of trials showed that when applied at early anthesis (Feekes 10.5.1) or within the first 6 days after anthesis (DAA), it was just as effective as Prosaro and Caramba (2,3). However, one of the primary questions addressed in the UFTs was whether Miravis Ace was just as effective when applied at Feekes 10.3 (early heading). If it is, this will extend the application window to as many as 10 days, allowing greater flexibility in terms of application timing. In addition, having a new, effective fungicide, particularly one of a different chemistry, and a wider application window will create opportunities for evaluating two-treatment fungicide programs for FHB and DON management. Several two-treatment programs were evaluated in this study. Results from the four years are summarized herein.

Materials and Methods: To accomplish the aforementioned objective, field experiments were conducted in 16 US wheat-growing states in 2018, 2019, 2020 and 2021. The standard protocol consisted of the application of the fungicide treatments in **Table 1** to plots of a susceptible cultivar. The experimental design was a randomized complete block, with at least 4 replicate blocks. In all experiments, plots were artificially inoculated with either *F. 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. 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. Separate 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) to evaluate treatment effects. Efficacy of fungicide treatment was estimated based on percent reduction in IND and DON relative to the nontreated check.

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, and timing
Core	
1	Nontreated check
2	Prosaro at 6.5 fl oz/A at anthesis
3	Caramba at 13.5 fl oz/A at anthesis
4	Miravis Ace at 13.7 fl oz/A at Feekes 10.3
5	Miravis Ace at 13.7 fl oz/A at anthesis
6	Miravis Ace at 13.7 fl oz/A at anthesis followed by Prosaro at 6.5 fl oz/A 4-6 DAA
7	Miravis Ace at 13.7 fl oz/A at anthesis followed by Caramba at 13.5 fl oz/A 4-6 DAA
Optional	
8	Miravis Ace at 13.7 fl oz/A at anthesis followed by tebuconazole at 4 fl oz/A 4-6 DAA
9	Miravis Ace at 13.7 fl oz/A at 4-6 DAA

*DAA = days after anthesis

Results and Discussion: Mean Fusarium head blight index (IND) data from 68 environments and deoxynivalenol (DON) contamination data from 55 environments are summarized for different fungicide treatments in Figures 1A and 1B, respectively. IND ranged from 0 to 69% and DON from 0 to 39 ppm across environments. For both responses, the nontreated check has the highest means, whereas treatments that consisted of an early anthesis (Feekes 10.5.1) application of Miravis Ace followed by an application of Prosaro, Caramba, or tebuconazole at 4-6 DAA had the lowest means (**Fig. 1** and **2**).

FHB index: Means varied across 68 environments and among fungicide treatments, as shown by the distribution of data points around the median in Figure 1. All treatments resulted in significantly lower mean IND (on the arcsine square root-transformed scale) than the nontreated check (**Fig. 1A** and **2A**). A single application of Caramba, Prosaro, or Miravis Ace at Feekes 10.5.1 reduced mean IND by 56, 56, and 70%, respectively, relative to the nontreated check (**Fig. 2A**). A single application of Miravis Ace at early heading (Feekes 10.3) or at 4-6 DAA reduced mean IND by 56 and 65%, respectively. The greatest reductions in mean IND were observed with the sequential applications of Miravis Ace and a DMI, with percent control ranging from 75 (Miravis Ace followed by Prosaro, MIR_PRO) to 82% (Miravis Ace followed by tebuconazole, MIR_FOL). MIR_PRO was not significantly different (on the arcsine square root-transformed scale) from MIR_CAR (Miravis Ace followed by Caramba). MIR_PRO and MIR_FOL were significantly different from each other (**Fig. 2A**).

Deoxynivalenol: All treatments resulted in significantly lower mean DON contamination of grain (on the log-transformed scale) than the nontreated check (**Fig. 1B** and **2B**). All treatments with an

application at anthesis and/or within the first 6 DAA resulted in significantly lower mean DON than the early heading application of Miravis Ace (**Fig 2B**). Among the treatments with a single application at anthesis, Miravis Ace resulted in the highest percent reduction in mean DON (47%), followed by Prosaro (42%) and Caramba (40%). Treatments with sequential applications of Miravis Ace followed by a DMI had lower mean DON (1.4 to 1.5 ppm) than a single application of Miravis Ace at early head emergence (3.8 ppm), anthesis (2.5 ppm), or post-anthesis (2.3 ppm). Relative to the check, sequentially applied treatments reduced mean DON by 68 (MIR_CAR and MIR_FOL) and 69% (MIR_PRO).

As additional data become available, a more complete set of analyses will be performed. However, the results summarized herein suggest that an application of Miravis Ace at Feekes 10.3 may suppress FHB IND to levels comparable to those achieved with an anthesis application, but such an early application is considerably less effective than a single anthesis or post-anthesis application in terms of DON suppression. The most effective control is achieved when Miravis Ace is applied sequentially with a DMI fungicide.

Acknowledgements and Disclaimer: This material is based upon work supported by the U.S. Department of Agriculture, under Agreement Nos. 59-0206-8-195, 59-0206-0-126; 59-0206-9-120, 59-0206-0-125; 59-0206-6-008, 59-0206-0-153; 59-0206-5-007, 58-6070-9-019, 59-0206-0-184; 59-0206-8-192, 59-0206-0-115; 59-0206-8-189, 59-0206-0-138; 59-0206-5-005, 59-0206-9-122, 59-0206-0-139; 59-0206-8-190, 59-0206-0-141; 59-0206-6-015, 59-0206-0-155; 59-0206-4-016, 59-0206-9-117, 59-0206-0-132; 59-0206-8-210, 59-0206-0-140; 59-0206-8-199, 59-0206-0-122; 59-0206-8-211, 59-0206-0-144; 59-0206-0-173; 59-0206-0-188; 58-2050-8-013, 59-0206-0-175; 59-0206-6-010; 59-0206-8-189; 59-0206-0-179; 59-0206-6-012, 59-0206-0-189; 59-0206-9-123, 59-0206-0-118; 59-0206-6-014, 59-0206-0-191; 59-0206-9-009, 59-0206-0-185; and 59-0206-8-187, 59-0206-0-131. This is a cooperative project with the U.S. Wheat & Barley Scab Initiative. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the U.S. Department of Agriculture.

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.

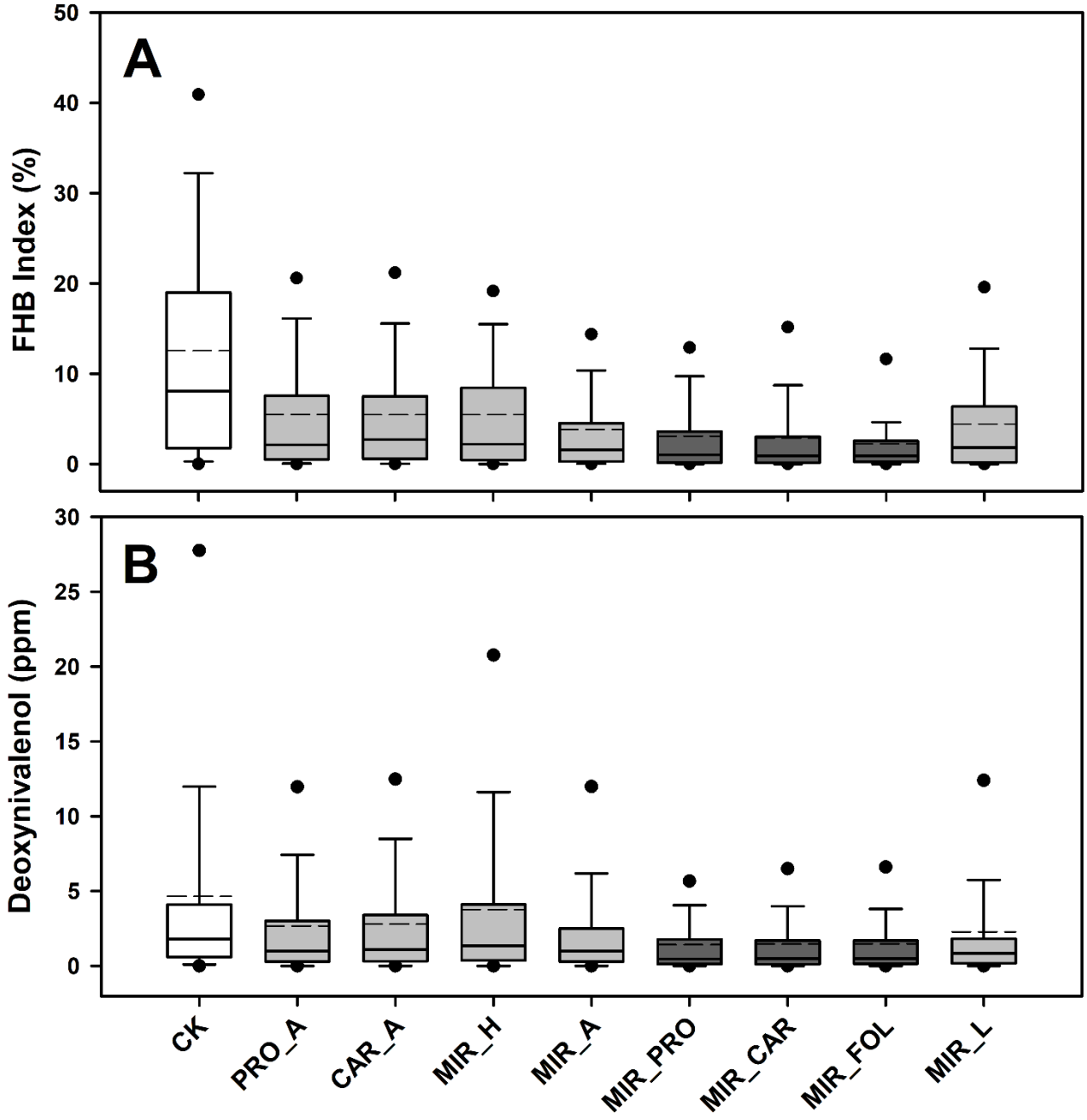

Fig. 1. Boxplots showing the distribution of **A**, mean Fusarium head blight index and **B**, deoxynivalenol grain contamination for different fungicide treatments. **PRO_A** = Prosaro at 6.5 fl. oz applied at anthesis, **CAR_A** = Caramba at 13.5 fl. oz applied at anthesis, **MIR_H** = Miravis Ace at 13.7 fl. oz applied at Feekes 10.3-5, **MIR_A** = Miravis Ace at 13.7 fl. oz applied at anthesis, **MIR_PRO** = Miravis Ace at anthesis followed by Prosaro 4-6 days later, **MIR_CAR** = Miravis Ace at anthesis followed by Caramba 4-6 days later, **MIR_FOL** = Miravis Ace at anthesis followed by Tebuconazole (4 fl. oz) 4-6 days later, and **MIR_L** = Miravis Ace applied at 4-6 days after anthesis.

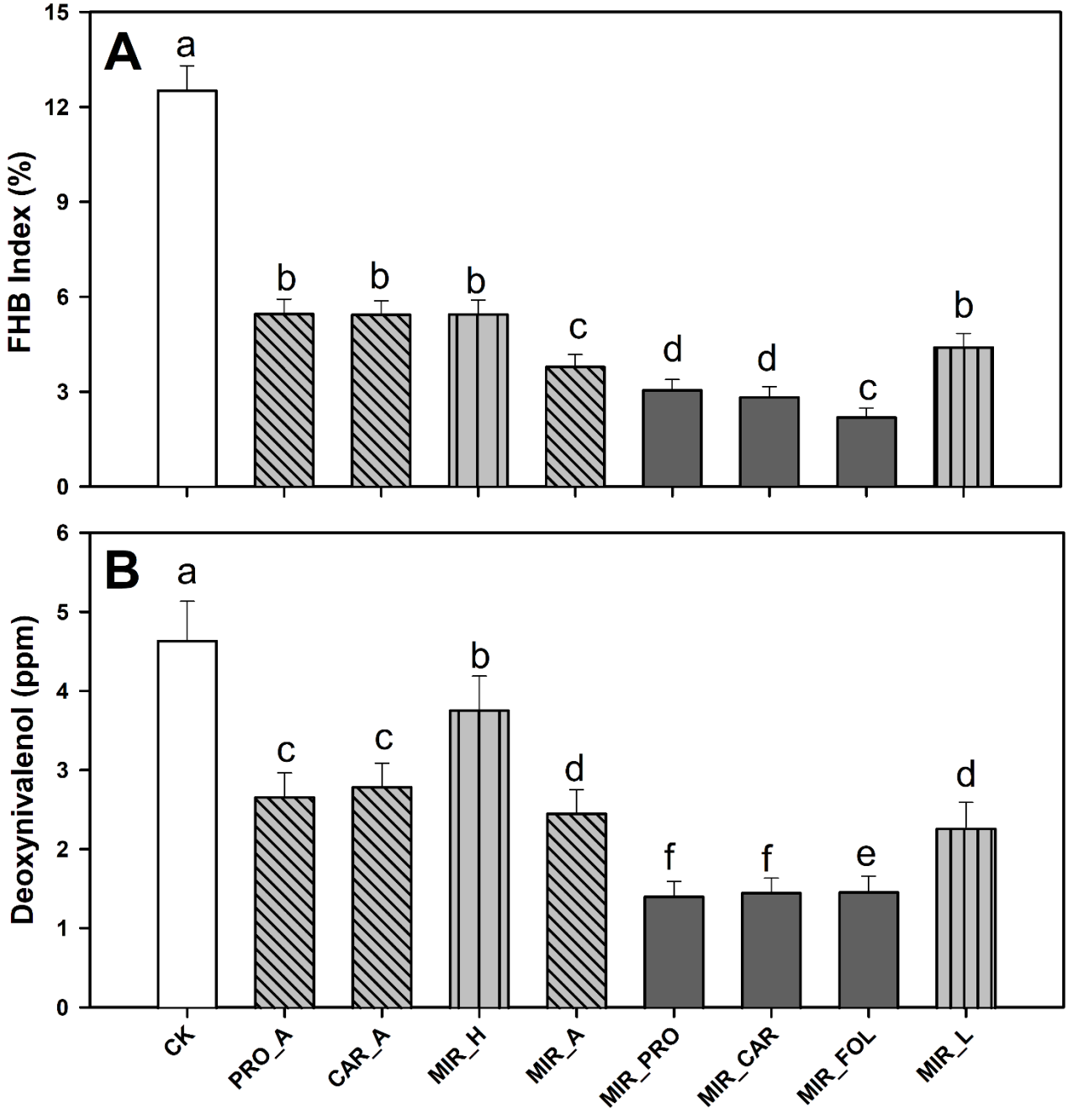

Fig 2. Mean **A**, Fusarium head blight index and **B**, deoxynivalenol grain contamination for different fungicide treatments. **PRO_A** = Prosaro at 6.5 fl. oz applied at anthesis, **CAR_A** = Caramba at 13.5 fl. oz applied at anthesis, **MIR_H** = Miravis Ace at 13.7 fl. oz applied at Feekes 10.3-5, **MIR_A** = Miravis Ace at 13.7 fl. oz applied at anthesis, **MIR_PRO** = Miravis Ace at anthesis followed by Prosaro 4-6 days later, **MIR_CAR** = Miravis Ace at anthesis followed by Caramba 4-6 days later, **MIR_FOL** = Miravis Ace at anthesis followed by Tebuconazole (4 fl. oz) 4-6 days later, and **MIR_L** = Miravis Ace applied at 4-6 days after anthesis. Models were fitted to data and means were compared on the arcsine square root-transformed scale for IND and log-transformed sale for DON, but graphs are shown on the raw data scale for convenience.