Fusarium Head Blight Management Coordinated Project: Integrated Management Trials 2022-2023

Comparative assessment of integrated effects of host resistance and two newly released fungicides against Fusarium head blight (FHB) and Deoxynivalenol (DON) management in wheat

Isaack Kikway[1], Wenderson B. Moraes[1], Shaukat Ali[2], Keith Ames[3], Gary Bergstrom[4], Mandy Bish[5], Kira Bowen[6], Carl Bradley[7], Martin Chilvers[8], Alyssa Collins[9], Christina Cowger[10], Heather Darby[11], Erick DeWolf[12], Ruth Dill-Macky[13], Paul Esker[14], Andrew Friskop[15], Alyssa Koehler[16], Laurence Madden[1], Juliet Marshall[17], Kelsey Onofre[12], Guy Padgett[18], Nidhi Rawat[19], Jessica Rutkoski[3], Damon Smith[20], Darcy Telenko[21], Stephen Wegulo[22], Heather Young-Kelly[23], and Pierce A. Paul[1*]

[1]The Ohio State University, Wooster, OH 44691; [2]South Dakota State University, Brookings, SD 57007; [3]University of Illinois, Urbana, IL 61801; [4]Cornell University, Ithaca, NY 14853; [5]University of Missouri, Columbia, MO 65201; [6]Auburn University, Auburn, AL 36849; [7]University of Kentucky, Princeton, KY 42445; [8]Michigan State University, East Lansing, MI 48824; [9]The Pennsylvania State University, Manheim, PA 17545; [10]North Carolina State University/USDA-ARS, Raleigh, NC 27695; [11]University of Vermont and State Agricultural College, St. Albans, VT 05478; [12]Kansas State University, Manhattan, KS 66506; [13]University of Minnesota, St. Paul, MN 55108; [14]The Pennsylvania State University, University Park, PA 16802; [15]North Dakota State University, Fargo, ND 58102; [16]The University of Delaware, Georgetown, DE 19947; [17]University of Idaho, Aberdeen, ID 83210; [18]Louisiana State University, Baton Rouge, LA 70803; [19]University of Maryland, College Park, MD 20742; [20]University of Wisconsin-Madison, Madison, WI 53706; [21]Purdue University, West Lafayette, IN 47907; [22]University of Nebraska-Lincoln, Lincoln, NE 68588; and [23]The University of Tennessee at Knoxville, Jackson, TN 38301

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

Introduction: Integrated approaches for managing Fusarium head blight (FHB) and deoxynivalenol (DON) contamination of grain include agronomic practices, resistant cultivars, and chemical control. Prothioconazole, metconazole, and tebuconazole are three of the most effective demethylation inhibitor (DMI) fungicide active ingredients (AIs) for FHB and DON control. The efficacy of Prosaro (a premix of the DMI AIs tebuconazole and prothioconazole) and Miravis® Ace (a premix of the DMI Propiconazole and the SDHI Pydiflumetofen), industry standards for FHB and DON management, has been well documented. Now it is informative to determine whether newly labeled products such as Prosaro Pro (a premix of the DMI AIs tebuconazole and prothioconazole and the SDHI Fluopyram) and Sphaerex (a premix of metconazole and prothioconazole) will be just as or more effective than the industry standards when used in combination with cultivar resistance. The focus of the integrated management coordinated project (IM_CP) during the 2022 and 2023 growing seasons was to determine whether newly registered fungicides such as 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 and 2023 growing seasons, field experiments were conducted in 24 US wheat-growing states. The standard protocol consisted of the application of the fungicide treatments in Table 1 (sub-plot) to plots of FHB-susceptible (S), -moderately susceptible (MS), and -moderately resistant (MR) cultivars (whole-plot). Hereafter, the combinations of fungicide programs by cultivar resistance classes will be referred to as: MR_CK (MR untreated), 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). When referring to the same fungicide programs applied to the MS and S cultivars, the combinations were labelled MS_CK, MS_I, MS_II, MS_III, MS_IV, S_CK, S_I, S_II, S_III and S_IV. The experimental design was a randomized complete block, with at least 4 replicate blocks. In most experiments, plots were spray inoculated with a spore suspension of the fungus *Fusarium graminearum* approximately 24-36 hours after the anthesis treatments were applied, with or without mist-irrigation. Trials were naturally infected at some locations. FHB index (IND) was rated or calculated as previously described (1,5) on 60-100 spikes per plot at approximately Feekes 11.2. Plots were harvested, and a grain sample from each experimental unit was sent to a USWBSI-supported laboratory for mycotoxin analysis. Separate linear mixed models (multi-location analysis) were fitted to arcsine square root-transformed IND and log-transformed DON data pooled across environments (trial x state x year combinations), with management combination (15 levels) as fixed effect and environment, block nested within environment, cultivar nested within block and environment as random effects. Contrasts were used to compare pairs of fungicide programs within each resistance class.

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)	Untreated 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: Figure 1 shows the distribution of mean Fusarium head blight index (IND) and deoxynivalenol (DON) grain contamination for each treatment combinations across up to 27 environments (18 in 2022 and 9 in 2023), representing spring and winter wheat growing regions with five wheat market classes (durum, hard red spring, hard red winter, soft red winter, and soft white winter).

FHB index: Mean IND varied across the 27 environments and 15 management combinations, ranging from 0 to 71% (**Fig 1A**). The susceptible, nontreated check (S_CK) had the highest mean IND (10.31%), whereas treatment combinations involving the application of Prosaro (I), Miravis Ace (II), Prosaro Pro (III), or Sphaerex (IV) at anthesis to MR cultivars has the lowest means (0.9,

0.7, 0.9, and 0.8%, respectively) (**Fig. 2A**). Within each resistance class, all fungicide treatments had significantly lower mean arcsine square root-transformed IND than the nontreated check (**Fig. 2A**).

Deoxynivalenol: Mean DON contamination of grain ranged from 0 to 30 ppm across the 27 environments and management combinations (**Fig. 1B**). Like IND, the lowest mean DON contamination was observed when either Prosaro (I), Miravis Ace (II), Prosaro Pro (III), or Sphaerex (IV) was applied at anthesis to MR cultivars, with means ranging between 0.6 to 0.8 ppm. The highest mean level of the toxin was observed in the untreated susceptible check (S_CK, 4.1 ppm) (**Fig. 2B**). Within each resistance class, all treatments resulted in significantly lower mean DON than the nontreated check on the log-transformed scale (**Fig. 2B**).

Efficacy of FHB management programs against IND and DON contamination of grain: Relative to the nontreated susceptible check (S_CK), integrated management programs that included one of the tested fungicides and an MR cultivar showed the highest percent control of IND (C = 91 to 92%) and DON (C = 82 to 86%), followed by programs that included an MS cultivar and a fungicide treatment (C = 84 to 86% for IND and 61 to 66% for DON), and lastly, those that consisted of S cultivars treated with a fungicide (C = 54 to 79% for IND and 57 to 68% for DON). Considering the efficacy of fungicide-only management programs (i.e. treatments applied to a susceptible cultivar), Miravis Ace, Sphaerex and Prosaro Pro were more effective against IND and DON, based on percent control, than Prosaro, the industry standard. For instance, relative to Prosaro (S_I), percent reduction in IND for S_II, S_III, and S_IV was 54, 40, and 29%, respectively. A similar trend was observed for DON, with S_II, S_III, and S_IV reducing DON contamination of grain by about 24%, 12%, and 3%, respectively, relative to S_I.

In summary, based on the analyses of the pooled 2022 and 2023 data collected so far, the newly released fungicides (Prosaro Pro and Sphaerex) were just as effective as the industry standard Prosaro against IND and DON when applied to MR or MS cultivars (i.e. when use in integrated management programs). However, when applied to a susceptible cultivar (i.e. fungicide-only management programs), Prosaro Pro and Sphaerex were more effective than Prosaro, based on percent control. As additional DON data from 2023 field trials become available, a more complete set of analyses will be performed. However, the results summarized herein suggest that the new fungicide mixtures were quite effective against FHB and DON, with the highest percent control when used in combination with genetic resistance. The experiments will be repeated in 2024 growing season, and all data will be pooled and analyzed to formally quantify management combination effects.

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. Paul, P. A., Salgado, J. D., Bergstrom, G. C., Bradley, C., Byamukama, E., Byrne, A. M., Chapara, V., Cummings, J. A., Chilvers, M. I., Dill-Macky, R., Friskop, A. J., Kleczewski, N. M., Madden, L. V., Nagelkirk, M., Stevens, J., Smith, M., Wegulo, S. N., Wise, K. A., and Yabwalo, D. 2019. Integrated effects of genetic resistance and prothioconazole tebuconazole application timing on Fusarium head blight in wheat. Plant Dis. 103:223-237.
4. 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.
5. Stack, R. W., and McMullen, M. P. 1998. A visual Scale to estimate severity of Fusarium head blight in wheat. NDSU Extension Service: Small Grains Publications. Online Publication/PP-1095.

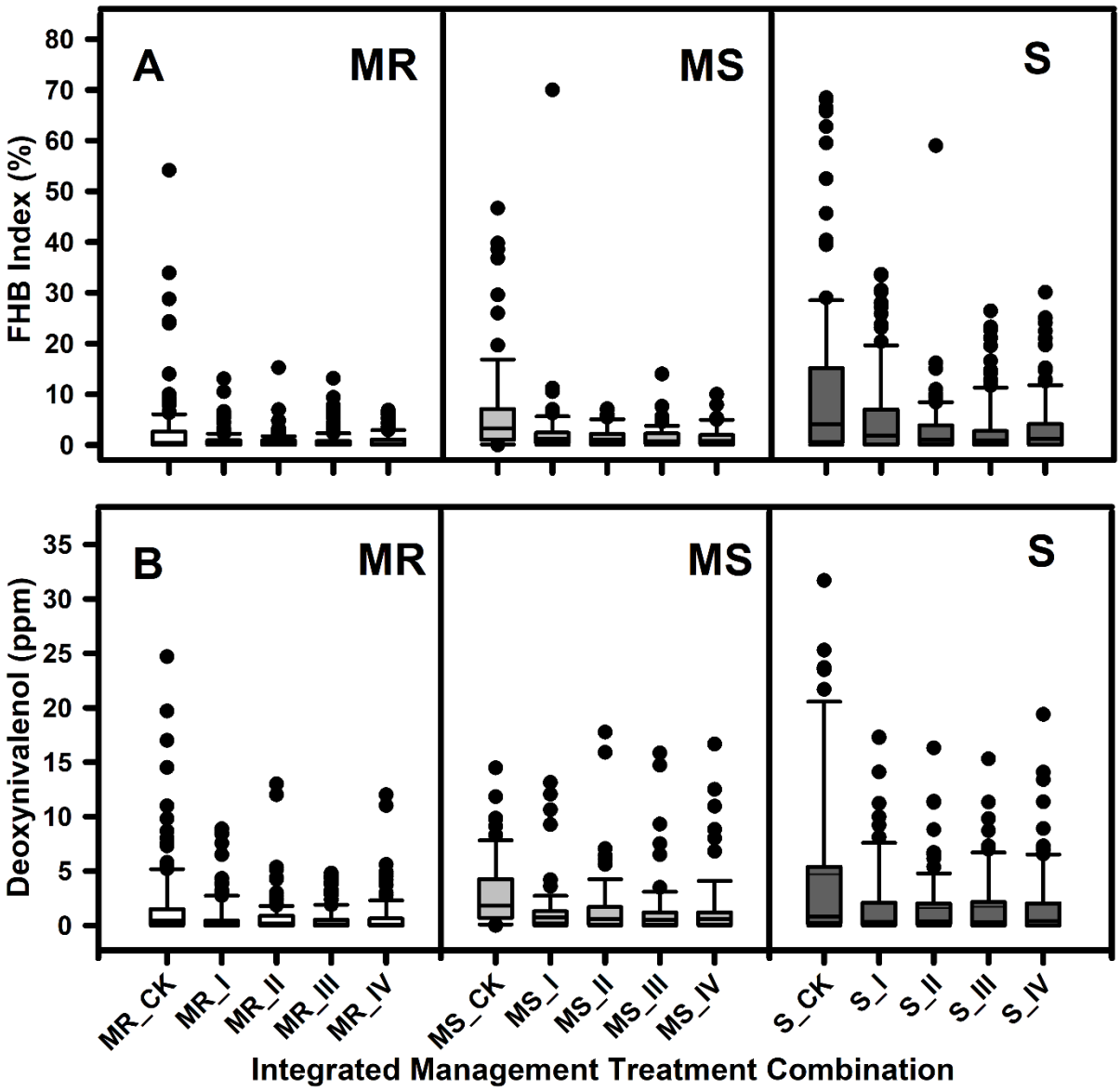

Fig. 1. Boxplots showing the distribution of **A**, mean Fusarium head blight index and **B**, deoxynivalenol grain contamination for different fungicide program x cultivar resistance management combinations. **S**, **MS**, and **MR** represent susceptible, moderately susceptible, and moderately resistant, respectively, whereas **CK** = nontreated check, **I** = treated with Prosaro (6.5 fl. oz.) at anthesis, **II** = treated with Miravis Ace (13.7 fl. oz.) at anthesis, **III** = treated with Prosaro Pro (10.3 fl. oz.) at anthesis, and **IV** = treated with Sphaerex (7.3 fl. oz.) at anthesis. For FHB index and DON, each box in **A** and **B** shows the distribution of mean FHB index across 16 and 9 trials from the 2022 and 2023 growing seasons, respectively.

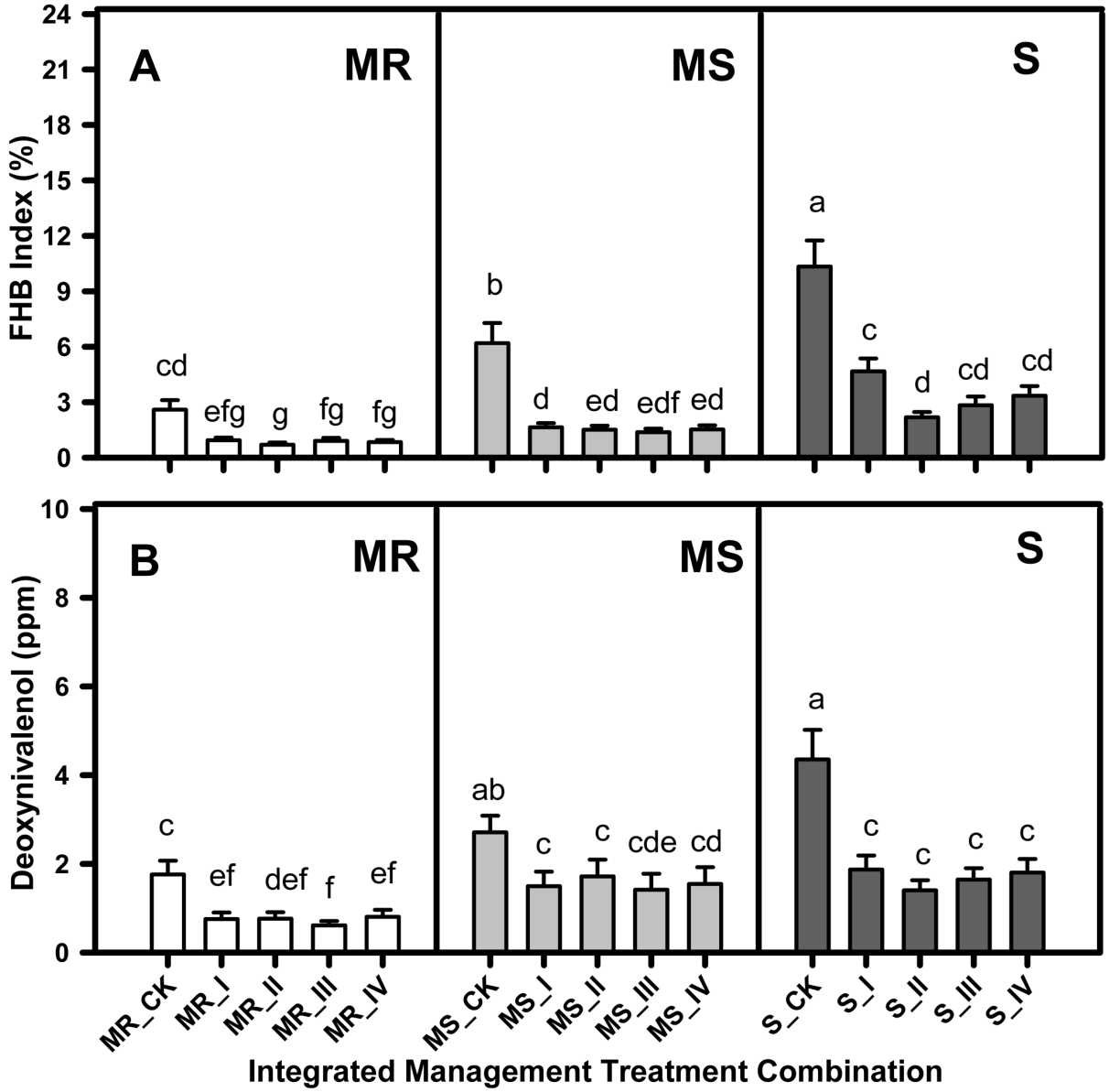

Fig. 2. Arithmetic mean **A**, Fusarium head blight index (IND) and **B**, deoxynivalenol (DON) grain contamination for different fungicide program x cultivar resistance management combinations. **S**, **MS**, and **MR** represent susceptible, moderately susceptible, and moderately resistant, respectively, whereas **CK** = nontreated check, **I** = treated with Prosaro (6.5 fl. Oz.) at anthesis, **II** = treated with Miravis Ace (13.7 fl. Oz.) at anthesis, **III** = treated with Prosaro Pro (10.3 fl. Oz.) at anthesis, and **IV** = treated with Sphaerex (7.3 fl. Oz.) at anthesis. Each bar in A and B shows the mean response averaged across 16 and 9 trials from the 2022 and 2023 growing season, respectively. 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 scale for DON. Graphs are shown on the raw data scale for convenience.