Efficacy of new Fungicides for Fusarium head blight (FHB) and Deoxynivalenol (DON) management in wheat: Uniform Fungicide Trials (2022-2024)

Kikway Isaack[1], Bish D. Mandy[2], Bradley A. Carl[3], Chilvers I. Martin[4], Collins A. Alyssa[5], Cowger Christina[6], Darby Heather[7], Esker D. Paul[8], Friskop J. Andrew[9], Higgins Douglas[10], Kelly M. Heather[11], Koehler M. Alyssa[12], Marshall M. Juliet[13], Mideros Santiago[14], Onofre A. Kelsey[15], Padget Guy[16], Rawat Nidhi[17], Shires K. Madalyn[18], Smith L. Damon[19], Telenko E. P. Darcy[20], Paul A. Pierce[1*]

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

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

Introduction: Fungicides are essential for Fusarium head blight (FHB) and deoxynivalenol (DON) management in small grain crops. However, for successful FHB control, fungicide application timing, rate, and product are all important. Recently, two fungicide mixtures, Sphaerex® (metconazole + prothioconazole) and Prosaro Pro® (tebuconazole + prothioconazole + Fluopyram), were introduced for FHB and DON management in wheat. However, it remains uncertain whether these new products are as effective or more effective than established industry standards such as Prosaro, Caramba, and Miravis Ace. One of the primary objectives of the current round of FHB Uniform Fungicide coordinated project is to evaluate and compare the efficacy of Prosaro Pro and Sphaerex to Prosaro, Caramba, and Miravis Ace when applied to a susceptible wheat cultivar 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, 2023 and 2024 growing seasons under varying environmental conditions across 20 wheat-growing states in the United States. The experiments followed a standardized protocol that involved applying the fungicide treatments outlined in Table 1 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	13.7/10.3	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
M-ERA	Miravis Era	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) index and DON: The distributions of mean IND and DON contamination across environments (locations and growing seasons) are shown for different fungicide programs in Figures 1A and 1B, respectively. Across location-years, mean IND ranged from 0 to 50%, and DON from 0 to 42 ppm. The standard anthesis-only application of Miravis Ace had the lowest means among single-treatment fungicide programs, with 50% of the values between 0.3 to 4.2% IND (**Fig. 1A)** and 0.14 to 2.32 ppm for DON (**Fig. 1 B**). Two-treatment programs consisting of sequential application of Miravis Ace at anthesis followed by Prosaro Pro or Sphaerex at 4 to 6 days after anthesis resulted in the lowest means of all tested treatment programs, with half of the values falling between 0.10 to 2.8% for IND and between 0.1 to 2.8 ppm for DON. Mean FHB index for Miravis Era ranged from 0 to 24%, while DON levels ranged from 0 to15 ppm.

Fusarium head blight (FHB) index: Compared to the nontreated check, all tested fungicide programs significantly reduced mean FHB index (on the arcsine square root-transformed scale) (**Fig. 2A**). A single application of Miravis Ace at anthesis resulted in significantly lower mean IND than a single application of Prosaro, Caramba, Prosaro Pro, or Sphaerex at anthesis (**Fig. 2A**). Furthermore, an anthesis application of Miravis Ace followed by a late application of Prosaro Pro or Sphaerex (**Fig. 2A)** resulted in significantly lower mean IND (on the transformed scale) than all tested treatments (**Fig. 2A**).

Deoxynivalenol (DON): 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**). Among the single-treatment fungicide programs, Miravis Ace resulted in significantly lower mean DON than to other anthesis-only treatments, except for Prosaro Pro and Sphaerex (**Fig. 2B**). Sequential applications of Miravis Ace at anthesis followed by Prosaro Pro or Sphaerex 4 to 6 days later achieved significantly lower mean DON contamination of grain than all other tested fungicide application programs (**Fig. 2B**).

Overall efficacy of FHB fungicide programs against IND and DON contamination of grain: Efficacy of the tested fungicide programs against IND and DON contamination of grain relative to nontreated check varied considerably among fungicide programs, with percent control (C) ranging from 48 to 75% for IND and 22 to 54% for DON. Among the single-application programs, **Miravis Ace** resulted in the highest percent reduction of IND (C = 67%) IND and DON (C = 41%) (**Fig 3A** and **3B**). Compared to the standard application of Prosaro at anthesis, Miravis Ace at anthesis reduced mean IND and DON by 39% and 18%, respectively. Except for Caramba, which was the least effective treatment, other single-application treatments (Prosaro, Prosaro Pro, Sphaerex and Miravis Era) were of comparable efficacy, with percent control values ranging from 59 and 67% for IND (Fig. 3A) and 30 and 54% for DON (Fig 3B). 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 more effective of all tested fungicide programs. These sequential applications programs resulted in approximately 24 to 29% reductions in IND and DON relative to Miravis Ace applied alone at anthesis.

The findings from this three-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 typically more effective in managing the FHB index and DON levels than single applications at anthesis. For example, programs involving an anthesis application of Miravis Ace followed by a later application of Prosaro Pro or Sphaerex resulted in greater efficacy against FHB index and DON than a single anthesis application of any of the tested fungicides. Additionally, preliminary results based on data from a single growing season (2024) showed that Miravis Era, a new product not yet registered for FHB and DON management, was of comparable to Prosaro, an industry standard for FHB and DON management, Prosaro Pro and Sphaerex, two relatively new fungicides. These experiments will be repeated, and the data will be analyzed to quantitatively assess efficacy and evaluate the additive effects of active ingredient mixtures and sequentially applied fungicide treatments.

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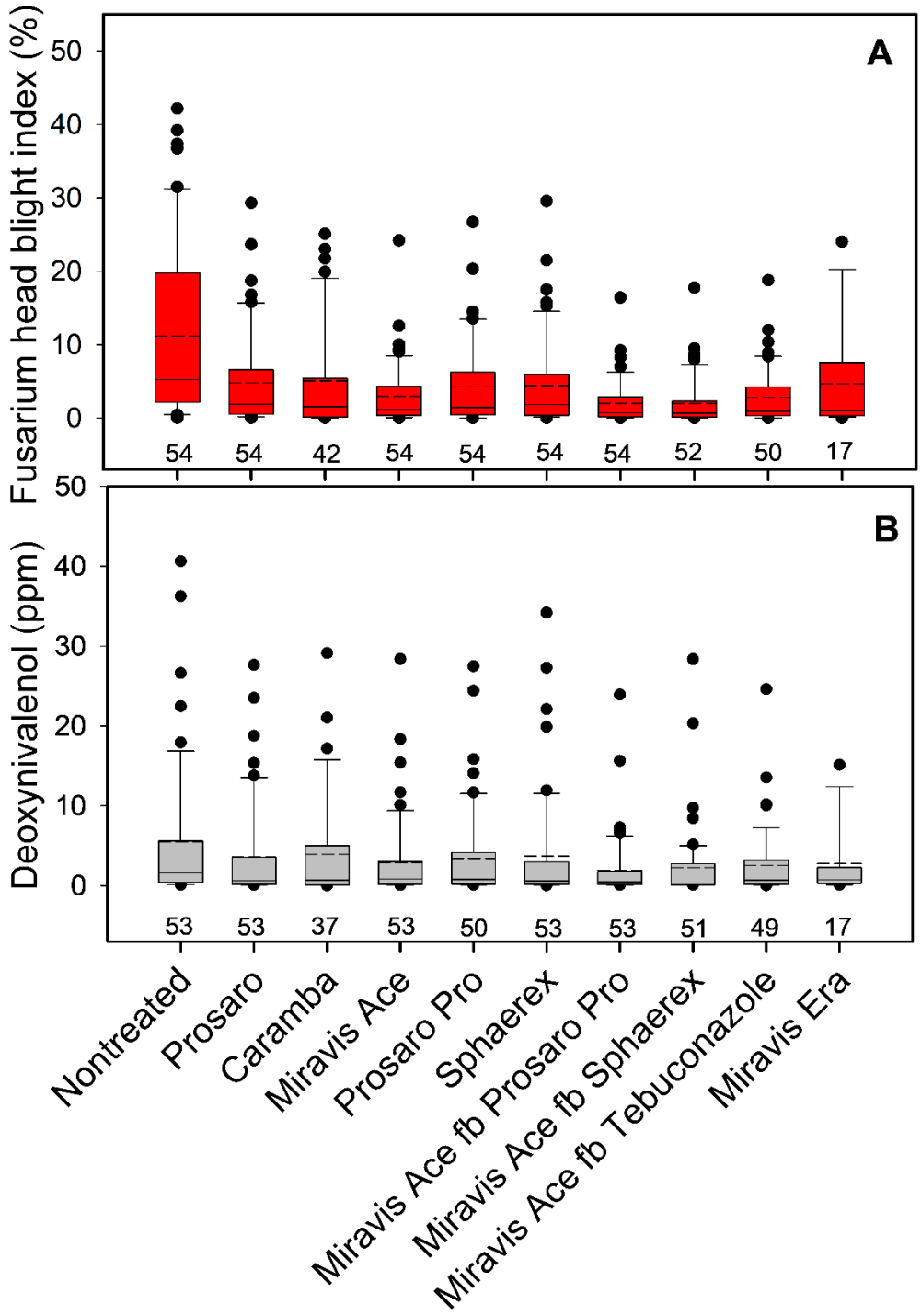

Fig. 1. Boxplots showing the distribution of least square mean Fusarium head blight (FBH) index (**A**) and deoxynivalenol (DON) grain contamination **(B)** for different fungicide treatments and a nontreated check. The tested treatments were: Prosaro (6.5 fl. oz.) applied at anthesis; Caramba (13.5 fl. oz.) applied at anthesis, Miravis Ace (13.7 fl. oz.) applied at anthesis, Prosaro Pro (10.3 fl. oz.) applied at anthesis; Sphaerex (7.3 fl. oz.) applied at anthesis; Miravis Ace applied at anthesis followed by Prosaro Pro 4-6 days later; Miravis Ace applied at anthesis followed by Sphaerex 4-6 days later; Miravis Ace applied at anthesis followed by Tebuconazole (4 fl. oz) 4-6 days later, and Miravis Era (10.2 fl. oz rat) at anthesis. Miravis Era was only tested in 2024. The horizontal, dashed lines represent the mean FHB index or DON contamination. Numbers above the x-axis indicate the number of trials in which each fungicide treatment was evaluated for its effect on each measured response.

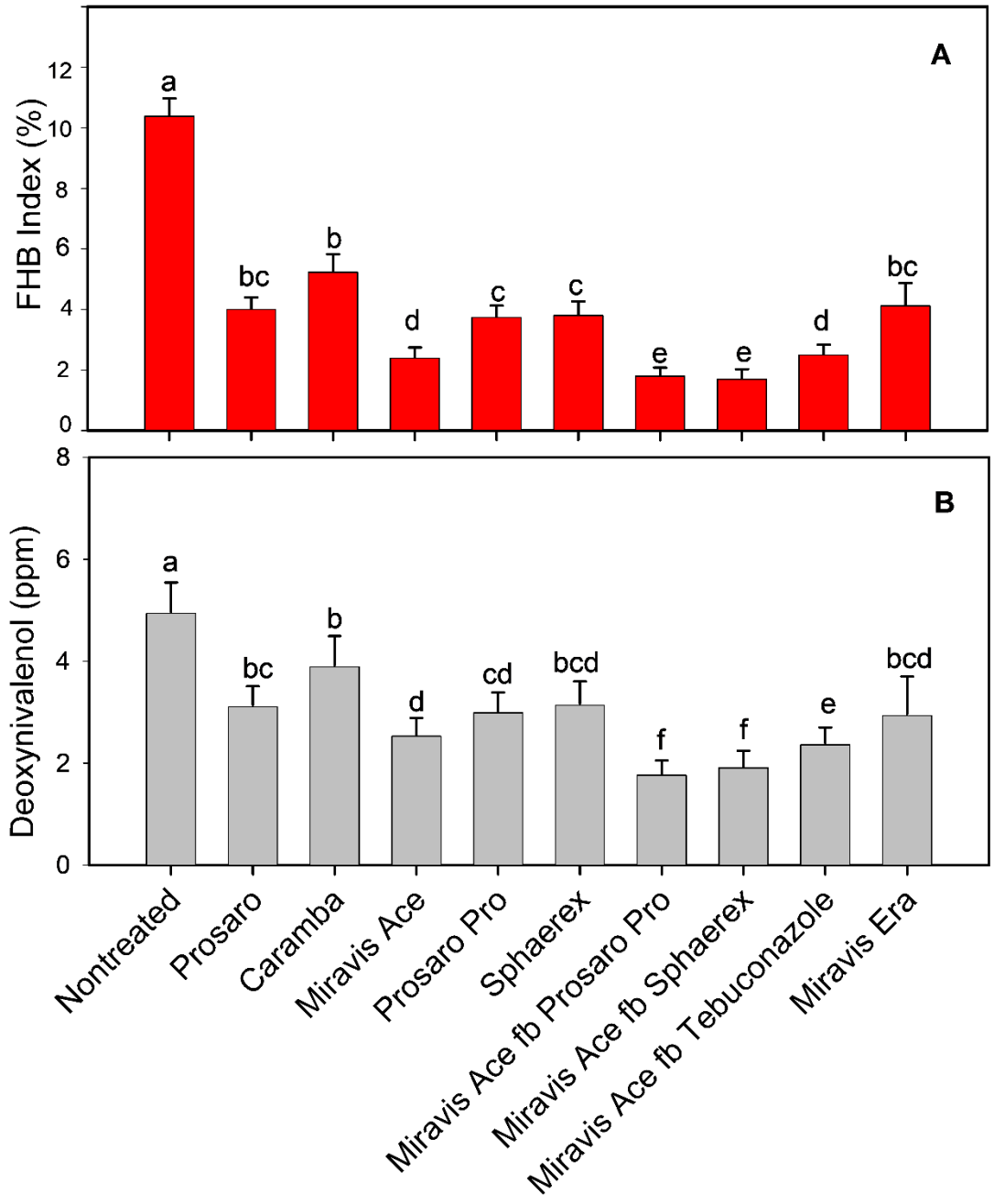

Fig 2. Mean Fusarium head blight index (A) and deoxynivalenol (DON) grain contamination (B) for different fungicide treatments and nontreated check. The tested treatments were: Prosaro (6.5 fl. oz.) applied at anthesis; Caramba (13.5 fl. oz.) applied at anthesis, Miravis Ace (13.7 fl. oz.) applied at anthesis, Prosaro Pro (10.3 fl. oz.) applied at anthesis; Sphaerex (7.3 fl. oz.) applied at anthesis; Miravis Ace applied at anthesis followed by Prosaro Pro 4-6 days later; Miravis Ace applied at anthesis followed by Sphaerex 4-6 days later; Miravis Ace applied at anthesis followed by Tebuconazole (4 fl. oz) 4-6 days later, and Miravis Era (10.2 fl. oz rat) at anthesis. Miravis Era was only tested in 2024. In panel **A,** each bar represents the mean Fusarium head blight index, while in panel B, each bar represents the mean DON contamination. Errors bars indicate standard errors of the mean. Statistical models were fit and means compared using arcsine square root transformation for FHB index and log transformation for DON, with fungicide treatments as a fixed effect. Graphs are presented on the raw data scale for clarity

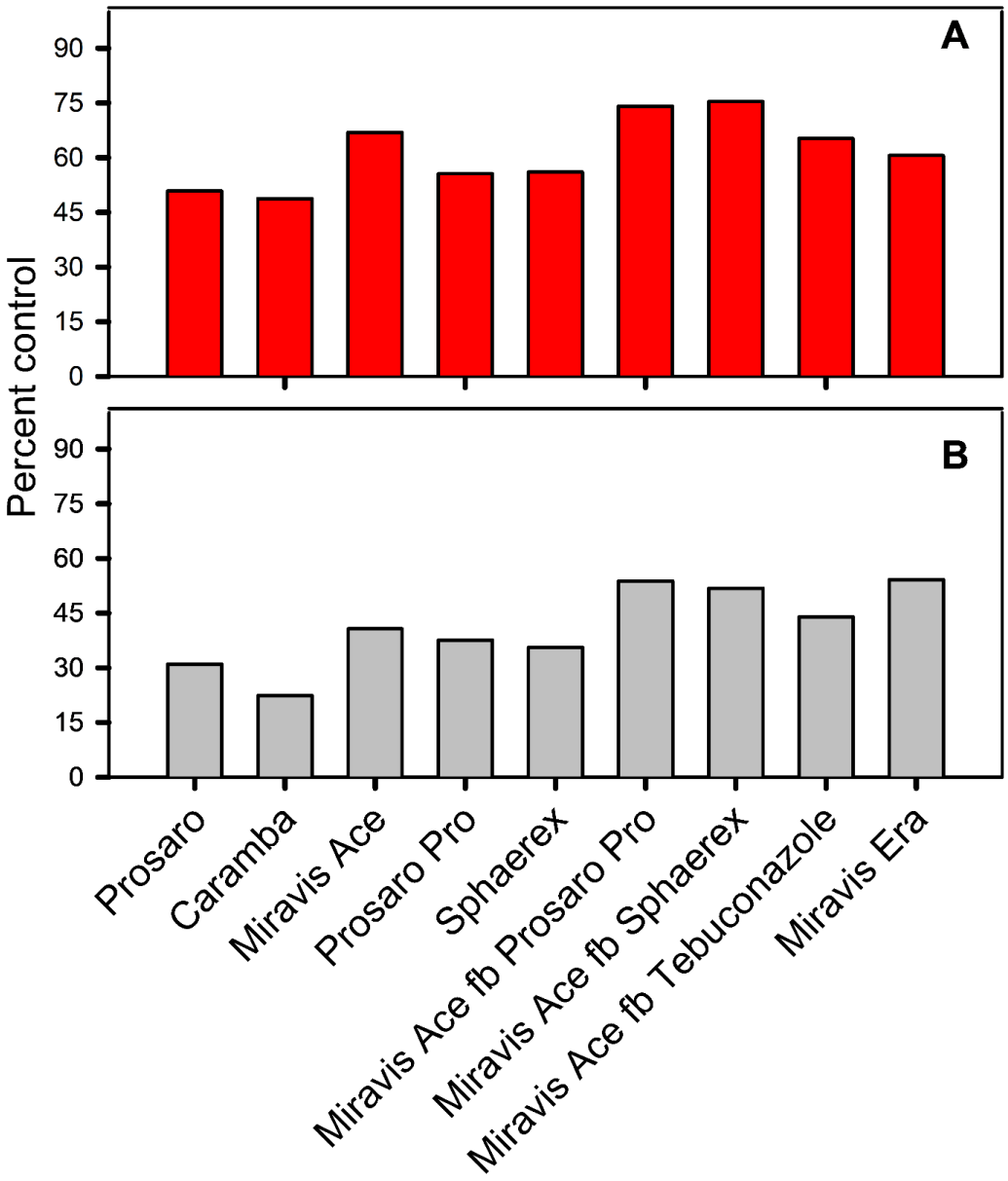

Fig. 3. Percent reduction in Fusarium head blight (FHB) index (A) and deoxynivalenol (DON) grain contamination (B) achieved by different fungicide treatments. The tested treatments were: Prosaro (6.5 fl. oz.) applied at anthesis; Caramba (13.5 fl. oz.) applied at anthesis, Miravis Ace (13.7 fl. oz.) applied at anthesis, Prosaro Pro (10.3 fl. oz.) applied at anthesis; Sphaerex (7.3 fl. oz.) applied at anthesis; Miravis Ace applied at anthesis followed by Prosaro Pro 4-6 days later; Miravis Ace applied at anthesis followed by Sphaerex 4-6 days later; Miravis Ace applied at anthesis followed by Tebuconazole (4 fl. oz) 4-6 days later, and Miravis Era (10.2 fl. oz rat) at anthesis. Miravis Era was only tested in 2024.