

2023 First Stripe Rust Forecast and 2022 Variety Yield Loss and Fungicide Tests

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A. The 2023 first forecast of stripe rust for the eastern Pacific Northwest

Based on the weather conditions in November and December 2022, stripe rust in the 2023 wheat growing season is forecasted to be in the lower range of moderate epidemic level (20-40% yield loss on susceptible varieties). Using forecast models based on the 2022 November and December weather data, yield loss of highly susceptible winter wheat varieties in the 2023 crop season is forecasted to be in the range of 16 to 33% with an average of **21%** using different models. This number is lower than the forecast (34%) made last January for the 2022 crop season due to the relatively cold weather of December 2022 compared to December 2021. Currently grown varieties are forecasted to be **0** to **15%** yield losses depending upon the level of resistance or susceptibility of individual varieties. Based on the forecast, fields grown with susceptible winter wheat varieties (stripe rust ratings 7 to 9) may need the early fungicide application at the time of herbicide application and varieties with ratings 0 to 6 may not need fungicide application. The early prediction made in January is often close to the real situation, but usually may not be as good as the prediction in March based on the entire winter weather. We will make another prediction in early March. However, stripe rust resistant or moderately resistant varieties (stripe rust ratings 1 to 4 in the Seed Buying Guide) should be planted for spring wheat crops.

B. Yield losses caused by stripe rust and increases by fungicide application on wheat varieties tested in 2022

The data of stripe rust and yield differences in non-sprayed and fungicide-sprayed plots in our experimental fields near Pullman in 2022 under artificial inoculation are shown in **Table 1** for winter wheat and **Table 2** for spring wheat.

Stripe rust was first observed in the susceptible check (PS 279) plots in the nursery on May 11, 2022 and reached 100% severity by June 21 at the heading to flowering stage (Feekes 10.2-10.51) in the non-sprayed susceptible check plots (**Table 1**). The two applications of Quilt Xcel at 14 fl oz/A reduced stripe rust severity, represented by relative area under the disease progress curve (rAUDPC), by 70.3% in the susceptible check plots. Due to the early inoculation of the pathogen and stripe rust favorable cool and wet weather conditions before July, the disease still caused substantial yield losses after the second fungicide application. The fungicide applications also significantly reduced rAUDPC of twelve commercially grown varieties (WB4303, UI Magic, LCS Jet, Otto, Mela CL+, Curiosity CL+, Puma, Keldin, SY Ovation, SY Clearstone 2CL, LCS Artdeco, and ARS-Crescent), and the reduction ranged from 9.0 to 58.4%. The fungicide applications significantly protected grain test weight of the susceptible check by 3.1 lb/bu and four commercial varieties (WB4303, UI Magic, LCS Jet, and Otto) by 1.5 to 14.3 lb/bu. The fungicide applications made significant yield differences for the susceptible check (53.4 bu/A more in the sprayed plots) and seventeen commercial varieties (WB4303, UI Magic,

LCS Jet, Otto, Mela CL+, ORCF-102, Curiosity CL+, Puma, Keldin, SY Ovation, LCS Drive, SY Assure, SY Clearstone 2CL, Resilience CL+, LCS Artdeco, Northwest Tandem, and Jasper) with 9.7 to 68.3 bu/A more grain in the sprayed plots. The remaining six commercial varieties (SY Dayton, WB1604, ARS-Crescent, M-Press, Northwest Duet, and Bruehl) showed no significant yield differences between the no-spray and spray treatments. These data indicated that stripe rust caused yield loss of 53.4 bu/A (87.6%) on the susceptible check and 16.8 bu/A (14.4%) yield loss on average across the commercially grown varieties under the extremely severe disease pressure in the experimental field due to the early inoculation and stripe rust favorable weather conditions in May to July 2022. Among the 23 commercial varieties, WB4303 and UI Magic were most susceptible, losing 64.1% and 44.4% yield without fungicide application. Under the severe stripe rust epidemic, eleven commercial varieties (WB4303, UI Magic, LCS Jet, Otto, Mela CL+, ORCL-102, Curiosity CL+, Puma, Keldin, SY Ovation, and LCS Drive) received fungicide application ratings 2 or higher (need fungicide application). Nine varieties (SY Assure, SY Clearstone 2CL, Resilience CL+, LCS Artdeco, Northwest Tandem, Jasper, SY Dayton, WB1604, and ARS-Crescent) were rated 1 (may or may not need fungicide application). The remaining three varieties (M-Press, Northwest Duet, and Bruehl) received fungicide application rating 0 (no need fungicide application).

Of the 24 spring wheat varieties tested including 23 commercial varieties and one susceptible check ('AvS'), 9 varieties (AvS, WB6341, WB-1035CL+, Diva, Kelse, Buck Pronto, Whit, Louise, and Glee) had significant differences and 15 varieties (Net CL+, Alum, Melba, Ryan, Solano, WB9668, WB9662, SY Gunsight, WB7202CLP, Tekoa, Chet, SY Selway, Seahawk, JD, and Espresso) had no significant differences in stripe rust severity (presented as rAUDPC) (**Table 2**). The significant differences ranged from 9.9% to 98.1% rAUDPC. Three varieties (AvS, WB6341, and WB-1035CL+) had significant differences in grain test weight, and the significant differences were 6.7, 3.1, and 5.3 lb/A, respectively. Grain yield losses of sprayed and non-sprayed plots were significantly different for three commercial varieties (WB6341, WB-1035CL+, and Net CL+) in addition to the susceptible check (AvS). Stripe rust caused 51.9% yield loss on the susceptible check and from 0 to 36.5% (average 6.3%) yield losses on commercial varieties. Fungicide application increased grain yields by 0 to 57.4% (average 8.7%) on commercial varieties. Based on the percentages of yield losses, two commercial varieties (WB6341 and WB-1035CL+) received fungicide application ratings 2 to 3 (need fungicide application), six varieties (Net CL+, Diva, Kelse, Alum, Melba, and Ryan) rating 1 (may or may not need fungicide application), and the remaining 15 commercial varieties (Buck Pronto, Solano, WB9668, Whit, Louise, WB9662, Glee, Gunsight, WB7202CLP, Tekoa, Chet, SY Selway, Seahawk, JD, and Espresso) received rating 0 (no need fungicide application) under the severe epidemic level in 2022. The most susceptible commercial variety of spring wheat was WB6341, which had 36.5% yield loss in non-sprayed plots.

These data can be used to select stripe rust resistant varieties to plant and to determine if fungicide application is needed for a variety based on its relative yield loss and potential epidemic level. Based on the current forecasted epidemic level (21% yield loss on susceptible varieties) for 2023 (see above), fungicide application may be needed for the varieties with a fungicide application rating 2 or higher, or stripe rust ratings 7-9 as mentioned above. Varieties with fungicide application ratings 0 and 1, or stripe rust ratings 1 to 6 in the Seed Buying Guide, may not need fungicide application in 2023.

C. Fungicide tests in 2022

In 2022, 19 fungicide treatments, plus a non-treated check, were evaluated for stripe rust control efficacy on both winter wheat and spring wheat in fields near Pullman, Washington under artificial inoculation with stripe rust spores. The data can be used to select fungicides for control stripe rust when needed.

In the winter wheat field, stripe rust from inoculation was observed at 0.1% severity in some of the plots on May 10, the same day of the first fungicide application, and reached 100% severity at the flowering stage in the non-treated check and some treated plots by June 28 (**Table 3**). The rAUDPC values of all fungicide treatments were significantly less than the non-treated check. Two treatments (Trivapro 7.0 fl oz/A at Feekes 5 followed by Trivapro 13.7 fl oz/A at Feekes 8 and Prosaro 8.2 fl oz/A at Feekes 8) provided the best control of stripe rust. However, none of the treatments provided 100% protection as the relatively early inoculation and stripe rust favorable wet and cool weather conditions allowed the disease lasting long, resulting in the generally low yields in the experimental field. Three treatments (Miravis Ace 7.0 fl oz/A followed by Trivapro 2.2SE 13.7 fl oz/A, Trivapro 7.0 fl oz/A at Feekes 5 followed by Trivapro 13.7 fl oz/A at Feekes 8, and Prosaro 8.2 fl oz/A at Feekes 8) had higher test weight than the non-treated check. All treatments produced yield higher than the non-treated check with the treatment of Prosaro 8.2 fl oz/A at Feekes 8 producing the highest yield. The significant yield responses ranged from 10.0 bu/A (85.7%) by the treatment of Tilt 3.6EC 4.0 fl oz/A at Feekes 5 to 55.1 bu/A (469.6%) by the treatment of Prosaro 421SC 8.2 fl oz/A at Feekes 8.

In the spring wheat field, stripe rust was observed at 0.1% severity in majority of the plots on June 15, 20 days after inoculation, the same day of the first fungicide application, and reached 90-100% severity at the soft dough stage in the non-treated check plots by July 22 (**Table 4**). The rAUDPC values of all fungicide treatments were significantly less than the non-treated check. Four treatments (Trivapro 7.0 fl oz/A at Feekes 5 followed by Trivapro 13.7 fl oz/A at Feekes 10, Tilt 4 fl oz/A at Feekes 5 followed by Quilt Xcel 14.0 fl oz/A at Feekes 10, Miravis Ace 7.0 fl oz/A at Feekes 5 followed by Trivapro 13.7 fl oz/A at Feekes 10, and Quilt Xcel 14.0 fl oz/A at Feekes 10) reduced rAUDPC to below 10%. Except two treatments (Manzate Max 51.2 fl oz/A at Feekes 10 and Tilt 4 fl oz/A at Feekes 5), all treatments had higher test weight than the non-treated check. All treatments produced yield higher than the non-treated check. The significant yield responses ranged from 21.5 bu/A (51.9%) by the treatment of Manzate Max 51.2 fl oz/A at Feekes 10 to 46.7 bu/A (115.5%) by the treatment of ADM.03509.F.3.D 22.0 fl oz/A at Feekes 10.

Table 1. Differences in stripe rust severity (as rAUDPC), test weight, and yield in non-sprayed and fungicide-sprayed plots of winter wheat varieties tested under natural infection of the stripe rust pathogen near Pullman, WA in 2022

| Variety | rAUDPC (%) | | | Test Weight (LB/BU) | | | Yield (BU/A) | | | Yield loss (%) | Yield Inc. (%) | Relative | Rating ^b |
|--------------------|------------|--------------------|-----------|---------------------|--------------------|----------|--------------|--------------------|------------|----------------|----------------|----------------|---------------------|
| | No spray | Spray ^a | Reduction | No spray | Spray ^a | Increase | No spray | Spray ^a | Difference | by stripe rust | by fungicide | yield loss (%) | |
| PS 279 | 100.0 | 29.7 | 70.3 * | 46.9 | 49.9 | 3.1 * | 7.6 | 61.0 | 53.4 * | 87.6 | 705.3 | 100.0 | 6 |
| WB4303 | 77.5 | 19.2 | 58.4 * | 41.5 | 55.8 | 14.3 * | 38.3 | 106.6 | 68.3 * | 64.1 | 178.4 | 73.2 | 8 |
| UI Magic | 63.3 | 7.0 | 56.3 * | 55.1 | 59.0 | 3.9 * | 63.4 | 114.1 | 50.7 * | 44.4 | 79.9 | 50.7 | 6 |
| LCS Jet | 46.3 | 4.0 | 42.3 * | 59.1 | 61.0 | 2.0 * | 81.2 | 122.1 | 40.9 * | 33.5 | 50.3 | 38.2 | 5 |
| Otto | 28.0 | 4.6 | 23.4 * | 53.6 | 55.1 | 1.5 * | 77.5 | 99.7 | 22.2 * | 22.2 | 28.6 | 25.4 | 3 |
| Mela CL+ | 26.8 | 6.2 | 20.6 * | 55.2 | 56.2 | 1.1 | 86.3 | 107.6 | 21.3 * | 19.8 | 24.7 | 22.6 | 2 |
| ORCF-102 | 15.8 | 13.2 | 2.6 | 57.8 | 58.5 | 0.7 | 94.4 | 113.5 | 19.1 * | 16.8 | 20.2 | 19.2 | 2 |
| Curiosity CL+ | 42.2 | 9.3 | 32.9 * | 54.9 | 55.9 | 1.0 | 85.1 | 102.2 | 17.2 * | 16.8 | 20.2 | 19.2 | 2 |
| Puma | 16.9 | 3.9 | 13.0 * | 58.5 | 59.4 | 0.9 | 113.8 | 129.8 | 16.0 * | 12.3 | 14.0 | 14.0 | 2 |
| Keldin | 27.9 | 4.4 | 23.5 * | 61.9 | 62.8 | 0.9 | 104.8 | 118.7 | 13.9 * | 11.7 | 13.3 | 13.4 | 2 |
| SY Ovation | 12.5 | 2.4 | 10.2 * | 58.7 | 59.2 | 0.5 | 111.7 | 125.8 | 14.2 * | 11.2 | 12.7 | 12.8 | 2 |
| LCS Drive | 6.9 | 3.9 | 3.1 | 56.9 | 57.7 | 0.8 | 121.1 | 134.4 | 13.3 * | 9.9 | 10.9 | 11.3 | 2 |
| SY Assure | 3.0 | 2.6 | 0.4 | 60.5 | 60.9 | 0.4 | 118.9 | 131.7 | 12.8 * | 9.7 | 10.8 | 11.1 | 1 |
| SY Clearstone 2CL | 19.6 | 6.5 | 13.1 * | 59.2 | 60.2 | 1.1 | 102.7 | 113.4 | 10.8 * | 9.5 | 10.5 | 10.8 | 1 |
| Resilience CL+ | 10.9 | 8.9 | 2.0 | 59.3 | 59.6 | 0.3 | 122.0 | 133.8 | 11.7 * | 8.8 | 9.6 | 10.0 | 1 |
| LCS Artdeco | 16.4 | 3.0 | 13.4 * | 57.5 | 58.3 | 0.8 | 120.7 | 131.5 | 10.8 * | 8.2 | 8.9 | 9.3 | 1 |
| Northwest Tandem | 6.2 | 4.1 | 2.15 | 58.5 | 59.5 | 1.0 | 125.6 | 135.6 | 10.0 * | 7.4 | 8.0 | 8.4 | 1 |
| Jasper | 3.6 | 1.8 | 1.8 | 58.6 | 59.1 | 0.5 | 142.8 | 152.5 | 9.7 * | 6.4 | 6.8 | 7.3 | 1 |
| SY Dayton | 7.8 | 3.1 | 4.6 | 58.0 | 59.2 | 1.2 | 116.1 | 123.0 | 6.8 | 5.6 | 5.9 | 6.4 | 1 |
| WB1604 | 2.8 | 2.2 | 0.6 | 61.4 | 61.6 | 0.3 | 122.1 | 128.0 | 5.9 | 4.6 | 4.8 | 5.3 | 1 |
| ARS-Crescent | 14.0 | 5.0 | 9.0 * | 58.1 | 58.5 | 0.4 | 127.2 | 132.6 | 5.4 | 4.1 | 4.2 | 4.6 | 1 |
| M-Press | 9.2 | 7.1 | 2.1 | 58.7 | 59.4 | 0.7 | 121.2 | 124.9 | 3.7 | 3.0 | 3.1 | 3.4 | 0 |
| Northwest Duet | 9.4 | 3.7 | 5.6 | 59.5 | 59.9 | 0.4 | 130.3 | 132.6 | 2.3 | 1.7 | 1.8 | 2.0 | 0 |
| Bruehl | 6.1 | 4.8 | 1.3 | 55.9 | 55.6 | -0.3 | 126.8 | 127.1 | 0.3 | 0.2 | 0.2 | 0.2 | 0 |
| Mean | 23.9 | 6.7 | 17.2 * | 56.9 | 58.4 | 1.6 * | 102.6 | 120.9 | 18.4 * | 15.2 | 17.9 | 17.3 | |
| Mean (excl. PS279) | 20.6 | 5.7 | 14.9 * | 57.3 | 58.8 | 1.5 * | 106.7 | 123.5 | 16.8 * | 14.4 | 22.9 | 16.5 | |
| R ² | 1.0 | | | 1.0 | | | 1.0 | | | | | | |
| CV | 33.9 | | | 1.6 | | | 5.6 | | | | | | |
| p-value | <0.0001 | | | <0.0001 | | | <0.0001 | | | | | | |
| LSD (P = 0.05) | 7.2 | | | 1.3 | | | 8.8 | | | | | | |

^a Quilt Xcel at 14.0 fl oz/A was sprayed first time at early jointing stage (Feekes 4-5) on 10 May when stripe rust was absent in the field, and second time on 1 June when plants were at late jointing stage (Feekes 7-8) and the non-first spray PS279 plots had 0.5-5% rust severity.

^b Rating = the single digit number of yield difference/LSD. Varieties with rating 0 does not need fungicide application, those with rating 1 may or may not need fungicide application, and those with rating 2 or higher need application.

* The difference between the non-sprayed check and fungicide spray plots is significant at $P \leq 0.05$.

Table 2. Differences in stripe rust severity (as rAUDPC), test weight, and yield in non-sprayed and fungicide sprayed plots of spring wheat varieties tested under natural infection of the stripe rust pathogen near Pullman, WA in 2022

| Variety | rAUDPC (%) | | | Test Weight (LB/BU) | | | Yield (BU/A) | | | Yield loss (%) | Yield Inc. (%) | Relative | Rating ^b |
|------------------|------------|--------------------|-----------|---------------------|--------------------|----------|--------------|--------------------|------------|----------------|----------------|----------------|---------------------|
| | No spray | Spray ^a | Reduction | No spray | Spray ^a | Increase | No spray | Spray ^a | Difference | by stripe rust | by fungicide | yield loss (%) | |
| AvS | 100.0 | 1.9 | 98.1 * | 53.1 | 59.7 | 6.7 * | 36.5 | 75.9 | 39.4 * | 51.9 | 108.0 | 100.0 | 4 |
| WB6341 | 62.1 | 6.1 | 56.0 * | 56.7 | 59.8 | 3.1 * | 55.4 | 87.2 | 31.8 * | 36.5 | 57.4 | 70.2 | 3 |
| WB-1035CL+ | 59.1 | 5.1 | 54.1 * | 50.8 | 56.1 | 5.3 * | 40.2 | 61.8 | 21.6 * | 34.9 | 53.6 | 67.2 | 2 |
| Net CL+ | 9.3 | 3.1 | 6.1 | 58.0 | 59.7 | 1.7 | 48.2 | 61.3 | 13.1 * | 21.4 | 27.2 | 41.2 | 1 |
| Diva | 13.7 | 3.0 | 10.7 * | 56.5 | 56.7 | 0.2 | 48.0 | 56.0 | 8.0 | 14.2 | 16.6 | 27.4 | 1 |
| Kelse | 34.0 | 4.2 | 29.8 * | 56.7 | 58.4 | 1.7 | 59.0 | 66.7 | 7.7 | 11.5 | 13.0 | 22.2 | 1 |
| Alum | 9.4 | 5.0 | 4.4 | 57.5 | 58.8 | 1.3 | 47.6 | 53.2 | 5.6 | 10.5 | 11.8 | 20.3 | 1 |
| Melba | 3.4 | 2.0 | 1.3 | 57.6 | 58.5 | 0.9 | 51.5 | 56.7 | 5.2 | 9.1 | 10.0 | 17.5 | 1 |
| Ryan | 9.6 | 4.8 | 4.9 | 56.5 | 57.1 | 0.6 | 89.2 | 94.2 | 5.0 | 5.3 | 5.6 | 10.2 | 1 |
| Buck Pronto | 22.6 | 5.3 | 17.4 * | 56.4 | 56.1 | -0.3 | 54.2 | 58.4 | 4.2 | 7.2 | 7.8 | 13.9 | 0 |
| Solano | 13.5 | 8.2 | 5.3 | 56.7 | 58.5 | 1.9 | 69.1 | 73.2 | 4.1 | 5.6 | 5.9 | 10.7 | 0 |
| WB9668 | 4.2 | 2.6 | 1.6 | 58.7 | 59.5 | 0.8 | 63.0 | 65.9 | 2.9 | 4.4 | 4.6 | 8.6 | 0 |
| Whit | 23.9 | 5.9 | 18.0 * | 54.6 | 54.7 | 0.1 | 56.8 | 59.1 | 2.3 | 3.9 | 4.0 | 7.4 | 0 |
| Louise | 14.0 | 2.9 | 11.1 * | 52.1 | 51.6 | -0.5 | 43.3 | 45.2 | 1.9 | 4.3 | 4.4 | 8.2 | 0 |
| WB9662 | 3.6 | 2.0 | 1.6 | 57.5 | 58.2 | 0.7 | 66.6 | 67.9 | 1.3 | 1.9 | 2.0 | 3.7 | 0 |
| Glee | 13.6 | 3.7 | 9.9 * | 57.7 | 58.2 | 0.5 | 67.8 | 68.2 | 0.4 | 0.6 | 0.6 | 1.1 | 0 |
| SY Gunsight | 2.6 | 2.0 | 0.6 | 56.8 | 59.1 | 2.3 | 76.9 | 77.3 | 0.4 | 0.5 | 0.5 | 0.9 | 0 |
| WB7202CLP | 8.0 | 3.2 | 4.8 | 58.3 | 58.2 | -0.1 | 76.3 | 76.4 | 0.1 | 0.1 | 0.1 | 0.3 | 0 |
| Tekoa | 3.0 | 2.5 | 0.5 | 57.9 | 58.2 | 0.3 | 61.2 | 60.6 | -0.5 | -0.9 | -0.9 | -1.7 | 0 |
| Chet | 8.0 | 4.2 | 3.9 | 61.1 | 61.3 | 0.3 | 64.1 | 62.8 | -1.3 | -2.1 | -2.0 | -4.0 | 0 |
| SY Selway | 8.3 | 6.1 | 2.2 | 55.4 | 55.7 | 0.3 | 59.8 | 58.3 | -1.5 | -2.6 | -2.6 | -5.0 | 0 |
| Seahawk | 2.5 | 1.9 | 0.6 | 58.2 | 57.2 | -1.0 | 60.6 | 57.9 | -2.7 | -4.7 | -4.5 | -9.1 | 0 |
| JD | 2.9 | 2.1 | 0.8 | 57.2 | 58.0 | 0.8 | 45.6 | 42.2 | -3.4 | -8.1 | -7.5 | -15.5 | 0 |
| Expresso | 4.3 | 6.8 | -2.6 | 58.1 | 58.9 | 0.8 | 74.3 | 68.8 | -5.5 | -8.0 | -7.4 | -15.4 | -1 |
| Mean | 18.1 | 3.9 | 14.2 * | 56.7 | 57.8 | 1.2 | 59.0 | 64.8 | 5.8 | 8.2 | 12.8 | 15.9 | |
| Mean (excl. AvS) | 14.6 | 4.0 | 10.6 * | 56.8 | 57.8 | 0.9 | 59.9 | 64.3 | 4.4 | 6.3 | 8.7 | 12.2 | |
| R ² | 0.9 | | | 0.6 | | | 0.8 | | | | | | |
| CV | 46.5 | | | 3.7 | | | 11.2 | | | | | | |
| p-value | <0.0001 | | | <0.0001 | | | <0.0001 | | | | | | |
| LSD (P = 0.05) | 7.2 | | | 3.0 | | | 9.7 | | | | | | |

^a Quilt Xcel at 14.0 fl oz/A was applied at jointing stage (Feekes 5) on 15 June when stripe rust just appeared with 0.1% severity on susceptible variety plots, and second time on 1 July at late jointing stage (Feekes 8) when non-first sprayed AvS plots had 15-20% severity.

^b Rating = the single digit number of yield difference/LSD. Varieties with rating 0 do not need fungicide application, those with rating 1 may or may not need fungicide application, and those with rating 2 or higher need application.

* The difference between the non-sprayed check and fungicide spray plots is significant at $P \leq 0.05$.

Table 3. Stripe rust severities and relative area under the disease progress curve (AUDPC), test weight, and yield in susceptible winter wheat (‘PS 279’) field plots not sprayed (No fungicide) or sprayed with various fungicide treatments under natural infection of the stripe rust pathogen near Pullman, WA in 2022

| Treatment | | Stripe rust severity (%) ^c | | | | | | | | | | Test weight ^c (lb/bu) | Yield | |
|-----------|--|---------------------------------------|-------------|---------|----------|-----------|----------|----------|-----------------------------|---------------|---------|-------------------------------------|-------|--|
| | | 10 May | 31 May | 14 Jun | 21 Jun | 28 Jun | 5 Jul | Relative | Mean ^c (bu/A) | Increase % | | | | |
| No. | Fungicide, rate, timing ^{a,b} | E jointing | L. jointing | Boot | Heading | Flowering | Milk | AUDPC | | | | | | |
| 1 | No fungicide | 0.00 B | 4.0 A | 52.5 A | 98.8 A | 100.0 A | 100.0 A | 100.0 A | | 48.6 C-E | 11.8 I | | 0.0 | |
| 2 | Miravis Ace 7.0 fl oz/A at Fks 5; Trivapro 13.7 fl oz/A at Fks 8 | 0.00 B | 0.5 EF | 8.0 EF | 32.5 CD | 56.3 E | 66.3 EF | 40.0 G-I | | 51.7 A | 57.3 BC | | 387.2 | |
| 3 | Trivapro 7.0 fl oz/A at Fks 5; Trivapro 13.7 fl oz/A at Fks 8 | 0.00 B | 0.0 F | 2.5 F | 25.0 DE | 56.3 E | 56.3 F | 33.5 U | | 50.7 AB | 60.2 B | | 412.6 | |
| 4 | ADM.03509.F.3.B 11.0 fl oz/A at Fks 8 | 0.00 B | 1.8 B-F | 1.5 F | 40.0 BC | 87.5 A-C | 95.0 A-C | 53.8 C-E | | 46.2 F-I | 40.3 F | | 243.0 | |
| 5 | ADM.03509.F.3.B 16.5 fl oz/A at Fks 8 | 0.00 B | 3.3 A-D | 2.0 F | 21.3 DE | 78.8 B-D | 92.5 A-D | 46.6 E-G | | 48.1 C-F | 45.2 EF | | 284.7 | |
| 6 | ADM.03509.F.3.B 22.0 fl oz/A at Fks 8 | 0.00 B | 2.6 A-D | 2.5 F | 26.3 DE | 85.0 B-D | 92.5 A-D | 49.7 C-F | | 48.3 C-E | 52.6 CD | | 347.4 | |
| 7 | ADM.03506.F.1.C 24.5 fl oz/A at Fks 8 | 0.00 B | 2.8 A-D | 6.0 EF | 30.0 CD | 88.8 A-C | 95.0 A-C | 54.0 C-E | | 46.7 E-I | 53.5 CD | | 355.3 | |
| 8 | ADM.03506.F.1.C 49.0 fl oz/A at Fks 8 | 0.00 B | 1.3 D-F | 3.3 F | 16.3 E | 78.8 B-D | 86.3 B-D | 43.3 F-H | | 47.7 C-G | 52.1 CD | | 343.6 | |
| 9 | ADM.03509.F.3.D 11.0 fl oz/A at Fks 8 | 0.03 AB | 3.8 AB | 3.5 F | 30.0 CD | 91.3 AB | 96.3 AB | 47.3 C-E | | 47.3 C-G | 43.8 F | | 273.0 | |
| 10 | ADM.03509.F.3.D 22.0 fl oz/A at Fks 8 | 0.03 AB | 3.3 A-D | 3.0 F | 22.5 DE | 81.3 B-D | 91.3 A-D | 48.0 D-G | | 48.1 C-F | 49.8 DE | | 323.8 | |
| 11 | PROLINE 480 SC 4.0 fl oz/A at Fks 8 | 0.03 AB | 2.1 A-E | 9.8 EF | 33.8 B-D | 88.8 A-C | 97.5 A | 56.7 CD | | 47.1 E-I | 42.9 F | | 265.1 | |
| 12 | MANZATE MAX 51.2 fl oz/A at Fks 8 | 0.00 B | 1.3 C-F | 28.8 BC | 93.8 A | 100.0 A | 100.0 A | 86.1 B | | 45.5 HI | 26.5 G | | 125.1 | |
| 13 | QUILT XCEL 14.0 fl oz/A at Fks 8 | 0.00 B | 3.5 A-C | 9.0 EF | 23.8 DE | 71.3 D | 82.5 D | 47.0 E-G | | 49.4 BC | 49.7 DE | | 322.8 | |
| 14 | PROSARO 8.2 fl oz/A at Fks 8 | 0.00 B | 2.3 A-E | 4.3 EF | 13.8 E | 36.3 F | 43.8 G | 24.8 J | | 52.3 A | 66.9 A | | 469.6 | |
| 15 | PRIAXOR 6.0 fl oz/A at Fks 8 | 0.03 AB | 3.5 A-C | 15.0 DE | 46.3 B | 75.0 CD | 90.0 A-D | 48.5 C | | 49.0 B-D | 49.8 DE | | 324.0 | |
| 16 | Tilt 4.0 fl oz/A at Fks 5 | 0.00 B | 0.0 F | 25.0 CD | 95.0 A | 100.0 A | 100.0 A | 83.7 B | | 45.3 I | 21.8 G | | 85.7 | |
| 17 | QUILT XCEL 14.0 fl oz/A at Fks 5 | 0.00 B | 0.0 F | 26.3 C | 95.0 A | 100.0 A | 100.0 A | 84.3 B | | 47.0 E-I | 25.3 G | | 115.3 | |
| 18 | TRIVAPRO 13.7 fl oz/A at Fks 5 | 0.05 A | 0.0 F | 37.5 B | 98.8 A | 100.0 A | 100.0 A | 90.4 B | | 45.8 G-I | 24.9 G | | 112.1 | |
| 19 | Tilt 4.0 fl oz/A at Fks 8 | 0.00 B | 1.5 C-F | 5.3 EF | 40.0 BC | 75.0 CD | 85.0 CD | 50.1 C-F | | 47.8 C-F | 52.4 CD | | 345.7 | |
| 20 | Tilt 4 fl oz/A at Fks 5; QUILT XCEL 14.0 fl oz/A at Fks 8 | 0.03 AB | 0.3 EF | 4.0 F | 25.0 DE | 51.3 E | 67.5 E | 34.6 HI | | 49.2 B-D | 50.3 DE | | 327.9 | |
| | R ² | 0.26 | 0.5 | 0.8 | 0.9 | 0.8 | 0.9 | 0.9 | | 0.7 | 1.0 | | | |
| | CV | 321.56 | 77.8 | 60.9 | 20.4 | 12.8 | 8.2 | 11.6 | | 2.8 | 8.4 | | | |
| | p-value | 0.38 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | | <0.0001 | <0.0001 | | | |
| | LSD (P ≤ 0.05) | 0.04 | 2.08 | 10.75 | 13.40 | 14.5 | 10.1 | 9.36 | | 1.91 | 5.21 | | | |

^a The application at Feekes 5 (early jointing) was done on 10 May, and at Feekes 8 (late jointing) on 1 June, 2022.

^b The field was under inoculations and natural infections of the wheat stripe rust pathogen.

^c Means sharing one or more letters are not significantly different at *P* = 0.05.

Table 4. Stripe rust severities and relative area under the disease progress curve (AUDPC), test weight, and yield in susceptible spring wheat ('AvS') field plots not sprayed (No fungicide) or sprayed with various fungicide treatments under natural infection of the stripe rust pathogen near Pullman, WA in 2022

| Treatment | | Stripe rust severity (%) ^c | | | | | | | Test weight ^c (lb/bu) | Yield | |
|-----------|---|---------------------------------------|----------|-----------|----------|----------|----------|-----------------------------|-------------------------------------|---------------|--|
| | | 15 Jun | 30 Jun | 8 Jul | 15 Jul | 22 Jul | Relative | Mean ^c (bu/A) | | Increase % | |
| No. | Fungicide, rate, timing ^{a,b} | E. jointing | Boot | Flowering | Milk | S. dough | AUDPC | | | | |
| 1 | No fungicide | 0.08 A | 12.5 AB | 47.5 A | 85.0 A | 97.5 A | 100.0 A | 54.0 D | 40.5 G | 0.0 | |
| 2 | Miravis Ace 7.0 fl oz/A at Fks 5; Trivapro 13.7 fl oz/A at Fks 10 | 0.05 A | 0.0 E | 2.5 D | 3.3 GH | 3.8 E | 3.8 HI | 59.9 A | 73.8 C-E | 82.5 | |
| 3 | Trivapro 7.0 fl oz/A at Fks 5; Trivapro 13.7 fl oz/A at Fks 10 | 0.10 A | 0.0 E | 2.3 D | 2.8 GH | 3.3 E | 3.3 I | 60.0 A | 83.6 AB | 106.7 | |
| 4 | ADM.03509.F.3.B 11.0 fl oz/A at Fks 10 | 0.10 A | 11.3 A-C | 11.3 B-D | 11.3 F-H | 13.8 E | 23.8 D-F | 59.6 A | 85.9 AB | 112.2 | |
| 5 | ADM.03509.F.3.B 16.5 fl oz/A at Fks 10 | 0.08 A | 15.0 A | 11.3 B-D | 11.3 F-H | 11.3 E | 26.2 D-F | 59.5 A | 79.7 A-C | 97.0 | |
| 6 | ADM.03509.F.3.B 22.0 fl oz/A at Fks 10 | 0.10 A | 11.3 A-C | 10.0 B-D | 10.0 F-H | 10.0 E | 21.6 D-G | 59.4 A | 64.7 EF | 59.9 | |
| 7 | ADM.03506.F.1.C 24.5 fl oz/A at Fks 10 | 0.08 A | 5.8 C-E | 7.0 B-D | 10.8 F-H | 12.0 E | 16.5 F-I | 58.9 A | 84.1 AB | 107.9 | |
| 8 | ADM.03506.F.1.C 49.0 fl oz/A at Fks 10 | 0.10 A | 6.3 B-E | 6.3 B-D | 10.0 F-H | 11.3 E | 15.9 F-I | 58.5 AB | 82.4 A-C | 103.7 | |
| 9 | ADM.03509.F.3.D 11.0 fl oz/A at Fks 10 | 0.08 A | 9.0 A-D | 7.8 B-D | 7.8 GH | 9.5 E | 17.4 E-H | 59.7 A | 85.6 AB | 111.5 | |
| 10 | ADM.03509.F.3.D 22.0 fl oz/A at Fks 10 | 0.75 A | 12.0 A-C | 10.8 B-D | 10.8 F-H | 10.8 E | 23.1 D-F | 59.8 A | 87.2 A | 115.5 | |
| 11 | PROLINE 480 SC 4.0 fl oz/A at Fks 10 | 0.10 A | 11.3 A-C | 12.5 BC | 20.0 EF | 27.5 D | 32.1 CD | 59.0 A | 79.2 A-C | 95.7 | |
| 12 | MANZATE MAX 51.2 fl oz/A at Fks 10 | 0.08 A | 8.8 A-D | 40.0 A | 66.3 B | 77.5 B | 79.1 B | 55.7 CD | 61.5 F | 51.9 | |
| 13 | QUILT XCEL 14.0 fl oz/A at Fks 10 | 0.08 A | 4.5 DE | 3.8 CD | 5.0 GH | 5.0 E | 9.3 G-I | 59.5 A | 86.9 A | 114.8 | |
| 14 | PROSARO 8.2 fl oz/A at Fks 10 | 0.08 A | 7.5 B-D | 8.8 B-D | 12.5 F-H | 15.0 DE | 20.4 D-G | 59.6 A | 81.8 A-C | 102.3 | |
| 15 | PRIAXOR 6.0 fl oz/A at Fks 10 | 0.10 A | 8.3 B-D | 10.8 B-D | 13.3 FG | 15.8 DE | 22.6 D-G | 58.9 A | 69.1 D-F | 70.8 | |
| 16 | Tilt 4.0 fl oz/A at Fks 5 | 0.08 A | 0.0 E | 14.5 B | 43.8 C | 63.8 C | 44.4 C | 53.9 D | 62.1 F | 53.5 | |
| 17 | QUILT XCEL 14.0 fl oz/A at Fks 5 | 0.05 A | 0.0 E | 5.0 CD | 31.3 D | 61.3 C | 32.8 CD | 56.4 BC | 76.7 B-D | 89.6 | |
| 18 | TRIVAPRO 13.7 fl oz/A at Fks 5 | 0.10 A | 0.0 E | 3.8 CD | 26.3 DE | 65.0 BC | 30.6 C-E | 58.5 AB | 68.5 D-F | 69.2 | |
| 19 | Tilt 4.0 fl oz/A at Fks 10 | 0.10 A | 5.8 C-E | 8.8 B-D | 12.5 F-H | 15.0 DE | 19.0 D-G | 60.4 A | 69.7 D-F | 72.3 | |
| 20 | Tilt 4 fl oz/A at Fks 5; QUILT XCEL 14.0 fl oz/A at Fks 10 | 0.05 A | 0.5 E | 2.3 D | 2.3 H | 3.0 E | 3.4 I | 60.2 A | 80.9 A-C | 99.9 | |
| | <i>R</i> ² | 0.20 | 0.6 | 0.8 | 0.9 | 0.9 | 0.9 | 0.6 | 0.8 | | |
| | CV | 49.61 | 68.8 | 58.8 | 37.7 | 36.5 | 36.1 | 2.8 | 8.7 | | |
| | <i>p</i> -value | 0.71 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | | |
| | LSD (<i>P</i> ≤ 0.05) | 0.06 | 6.30 | 9.43 | 10.5 | 13.7 | 13.92 | 2.34 | 9.22 | | |

^a The application at Feekes 5 (early jointing) was done on 15 June, and at Feekes 10 (boot) on 1 July, 2022.

^b The field was under inoculations and natural infections of the wheat stripe rust pathogen.

^c Means sharing one or more letters are not significantly different at *P* = 0.05.