2023 Wheat Variety Yield Loss and Fungicide Tests and Fall Stripe Rust Survey

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A. Yield losses caused by stripe rust and increases by fungicide application on wheat varieties tested in 2023

The experiment for assessing yield losses caused by stripe rust on 23 major winter wheat varieties grown in the Pacific Northwest (PNW), in comparison to susceptible check 'PS279', was conducted on the Palouse Conservation Farm Station (PCFS), near Pullman, WA in a randomized split-block design with four replications. The field was planted on October 19, 2022, and plants were inoculated with stripe rust spores collected from the same farm in 2022 at the tillering stage (Feekes 2-3) on April 10, 2023. Stripe rust started developing in the late May and reached 100% severity on the susceptible check plots without fungicide application before the end of June. Fungicide (Quilt Xcel at 14 fl oz/A) was sprayed at the early jointing stage (Feekes 5) on May 19 when stripe rust just started showing up and sprayed again at the boot stage (Feekes 10) on May 30 for the half number of plots to control stripe rust and left the second half number of plots unsprayed. Stripe rust was scored for infection type and severity for each plot five times during the rust season, and the relative area under the disease progress curve (rAUDPC) was calculated from the multiple sets of the severity data. Grain test weight and yield were measured and calculated after harvest. The average values of stripe rust rAUDPC, test weight, and yield for the no-spray and fungicide sprayed plots of the 24 varieties are shown in **Table 1**.

Under the stripe rust epidemic created by artificial inoculation, the disease reduced grain test weight by 5.4 pounds per bushel (9%) and grain yield by 32.6 bushels per acre (32.6%) on the susceptible check (PS279). On the 23 commercially growing varieties, the average yield loss was 6.7 bushels per acre (5%) and the average test weight reduction was 0.5 pounds per bushel (1%). Although better than the susceptible check, UI Magic had the highest yield reduction (27 bushels per acre or 21.6%) among the commercially grown varieties. Under the level of stripe rust, two varieties (UI Magic and LCS Jet), which received fungicide rating 2, need fungicide application, and eleven varieties (SY Assure, Pritchett, LCS Shine, Northwest Tandem, AP Exceed, Northwest Duet, LCS Jefe, LCS Artdeco, Resillence CL+, M-Press, and SY Dayton), which showed high-level of stripe rust resistance, did not have significant yield losses, and received fungicide rating 0, no need of fungicide application. The remaining ten varieties (Curiosity CL+, Otto, Mela CL+, LCS Hlk, ARS-Crescent, Sockeye CL+, Piranha CL+, Keldin, and WB4303) with fungicide rating 1 may or may not need fungicide aaplication.

Table 1. Differences in stripe rust rAUDPC and grain test weight and yield in no-spray and fungicide-sprayed plots of winter wheat varieties tested under the stripe rust epidemic created by artificial inoculation in the experimental field near Pullman, WA in 2023

Variety	CVR No.	rAUDPC (%)				Test Weight (LB/BU)				Yield (BU/A)				Yield loss (%) by stripe rust	Yield Inc. (%) by fungicide	Relative yield loss (%)	Rating[b]
		No spray	Spray[a]	Reduction		No spray	Spray[a]	Increase		No spray	Spray[a]	Difference					
PS 279	**1**	**100.0**	**1.9**	**98.1**	*	**55.5**	**60.9**	**5.4**	*	**67.3**	**99.8**	**32.6**	*	**32.6**	**48.4**	**100.0**	**3**
UI Magic	4	57.3	1.0	56.3	*	59.7	61.0	1.3	*	100.1	127.1	27.0	*	21.2	27.0	65.1	2
LCS Jet	14	19.0	1.3	17.7	*	60.9	61.9	1.0		119.2	138.6	19.4	*	14.0	16.3	42.9	2
Curiosity CL+	2	24.2	0.9	23.3	*	58.3	59.5	1.3	*	119.0	135.6	16.6	*	12.2	13.9	37.5	1
Otto	11	18.0	1.1	16.9	*	57.6	58.7	1.1		114.4	129.8	15.4	*	11.9	13.5	36.4	1
Mela CL+	15	13.3	0.8	12.5	*	57.9	58.5	0.6		126.8	141.0	14.3	*	10.1	11.2	31.0	1
Stingray CL+	9	16.9	1.3	15.6	*	57.5	59.1	1.6	*	126.9	138.9	12.0	*	8.6	9.5	26.5	1
LCS Hulk	3	2.4	1.1	1.3		61.1	61.1	0.0		137.2	145.8	8.6		5.9	6.3	18.1	1
ARS-Crescent	16	6.8	0.7	6.1	*	58.2	58.0	-0.2		125.4	133.8	8.4		6.3	6.7	19.3	1
Sockeye CL+	19	1.1	0.7	0.4		59.7	59.4	-0.3		140.0	148.2	8.2		5.5	5.8	16.9	1
Piranha CL+	24	8.2	0.8	7.4	*	59.2	59.9	0.7		134.1	142.0	7.9		5.6	5.9	17.2	1
Keldin	17	10.3	0.9	9.4	*	63.0	63.1	0.1		113.2	120.6	7.4		6.2	6.6	18.9	1
WB4303	22	30.7	2.2	28.5	*	61.2	61.8	0.7		105.2	111.6	6.4		5.7	6.0	17.5	1
SY Assure	18	2.6	1.0	1.6		62.2	62.4	0.3		120.2	123.8	3.6		2.9	3.0	9.0	0
Pritchett	7	6.4	1.2	5.2	*	58.0	58.7	0.6		118.7	121.9	3.2		2.6	2.7	8.1	0
LCS Shine	12	1.0	0.7	0.3		60.8	61.2	0.5		129.4	131.5	2.1		1.6	1.6	4.9	0
Northwest Tandem	23	1.6	0.8	0.8		59.9	60.5	0.6		135.3	136.9	1.7		1.2	1.2	3.7	0
AP Exceed	6	1.0	0.8	0.2		62.1	62.0	0.0		129.4	130.8	1.4		1.1	1.1	3.3	0
Northwest Duet	21	1.1	0.8	0.4		59.9	59.9	0.0		149.1	150.4	1.3		0.8	0.9	2.6	0
LCS Jefe	13	1.6	0.9	0.7		60.8	61.0	0.2		139.3	140.2	0.9		0.6	0.6	2.0	0
LCS Artdeco	5	4.7	1.5	3.3	*	60.7	60.9	0.2		128.0	128.4	0.3		0.3	0.3	0.8	0
Resilience CL+	10	2.4	1.1	1.3		59.8	60.6	0.8		129.8	127.7	-2.1		-1.7	-1.7	-5.2	0
M-Press	20	1.8	1.2	0.6		59.9	60.3	0.4		138.4	133.7	-4.8		-3.6	-3.4	-10.9	0
SY Dayton	8	3.0	0.8	2.2		60.4	60.9	0.5		120.3	114.9	-5.4		-4.7	-4.5	-14.5	0
Mean		14.0	1.0	12.9	*	59.8	60.5	0.7		123.6	131.4	7.8		5.9	6.3	18.1	
Mean (excl.PS279)		*10.2*	*1.0*	*9.2*	*	*59.9*	*60.4*	*0.5*		*126.1*	*132.7*	*6.7*		*5.0*	*5.7*	*15.3*	
R^2		**1.0**				**0.8**				**0.8**							
CV		**25.1**				**1.5**				**6.6**							
***p*-value**		**<0.0001**				**<0.0001**				**<0.0001**							
LSD (*P* = 0.05)		**2.6**				**1.2**				**11.7**							

[a] Quilt Xcel at 14.0 fl oz/A was sprayed first time at early jointing stage (Feekes 5) on 19 May when stripe rust was absent in the field, and second time on 30 May when plants were at boot stage (Feekes 10) and the non-first spray PS279 plots had 0-0.1% stripe 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 $P \leq 0.05$.

A similar experiment was conducted for 24 spring wheat varieties on the Spillman Farm, near Pullman. The field was planted on May 3, 2023, and the plants were inoculated with stripe rust spores on June 2 (Feekes 3-4) and June 7. Fungicide (Quilt Xcel 14 fl oz/A) was spayed on the fungicide-spray plots but not to the no-spray plots on June 7 (Feekes 4-5) and again June 21 (Feekes 9-10). Stripe rust infection and severity data were scored five times from Feekes 5 to Feekes 11.1. Grain yield and test weight were measured and calculated after harvest. The average values of stripe rust rAUDPC and grain test weight and yield are shown in **Table 2**. In this experiment, stripe rust did not develop to a uniform level (50 to 90% severity in the no-sprayed plots of the susceptible check AvS) before plants started maturing. None of the varieties, including the susceptible check, had significant yield loss. The yield data of the 23 commercially grown varieties, ranging from 57 to 114 bushels per acre, may be useful for selecting varieties to grow.

Table 2. Stripe rust (as rAUDPC) and grain test weight and yield in no-sprayed and fungicide-sprayed plots of spring wheat varieties under light stripe rust in the experimental field near Pullman, WA in 2023

Variety	CVR No.	rAUDPC (%) No spray	Spray[a]	Reduction		Test Weight (LB/BU) No spray	Spray[a]	Increase		Yield (BU/A) No spray	Spray[a]	Difference		Yield loss (%) by stripe rust	Yield Inc. (%) by fungicide	Relative yield loss (%)	Rating[b]
AvS	**1**	**100.0**	**0.3**	**99.8**	*	**57.6**	**58.3**	**0.7**		**75.8**	**79.6**	**3.8**		**4.8**	**5.0**	**100.0**	**0**
Chet	2	3.3	0.0	3.3		59.5	59.8	0.3		81.2	83.1	1.9		2.3	2.4	48.5	0
Louise	3	1.9	0.0	1.9		58.0	58.3	0.3		79.5	80.3	0.8		1.0	1.0	20.2	0
Tekoa	4	0.1	0.0	0.1		58.9	58.7	-0.2		97.8	97.5	-0.3		-0.3	-0.3	-6.4	0
Expresso	5	0.0	0.0	0.0		57.5	57.5	0.0		68.9	71.7	2.8		3.9	4.1	81.8	0
WB-1035CL+	6	29.4	0.0	29.4	*	57.8	58.1	0.4		88.0	83.7	-4.3		-5.2	-4.9	-108.2	0
Net CL+	7	3.7	0.0	3.7		60.3	60.8	0.4		81.8	82.0	0.2		0.2	0.2	5.1	0
WB9668	8	0.0	0.0	0.0		58.9	58.9	0.0		78.2	85.0	6.7		7.9	8.6	165.7	1
Hedge CL+	9	0.0	0.0	0.0		59.0	58.7	-0.3		86.8	84.7	-2.0		-2.4	-2.3	-50.0	0
Kelse	10	8.8	0.0	8.8	*	58.4	58.9	0.5		86.1	89.5	3.4		3.7	3.9	78.4	0
Roger	11	0.4	0.0	0.4		59.8	59.9	0.1		90.9	91.7	0.8		0.8	0.8	17.1	0
JD	12	0.0	0.0	0.0		58.5	58.9	0.3		77.6	79.2	1.6		2.0	2.1	42.3	0
Hale	13	0.0	0.0	0.0		60.2	60.2	0.0		87.6	78.8	-8.8		-11.2	-10.1	-233.9	-1
Jefferson	14	0.3	0.0	0.3		59.2	59.3	0.1		95.9	88.1	-7.8		-8.9	-8.1	-185.4	-1
Melba	15	0.0	0.0	0.0		58.5	58.7	0.2		86.0	90.1	4.1		4.6	4.8	95.3	0
Glee	16	0.4	0.0	0.4		59.5	59.4	-0.1		94.2	92.5	-1.6		-1.8	-1.8	-37.3	0
UI Stone	17	0.8	0.0	0.8		58.9	59.5	0.6		100.0	97.2	-2.8		-2.9	-2.8	-59.8	0
WB9662	18	0.0	0.0	0.0		57.4	57.7	0.3		57.0	57.7	0.7		1.2	1.2	25.4	0
Buck Pronto	19	7.2	0.0	7.2		57.3	58.4	1.1		85.8	89.0	3.2		3.6	3.7	74.7	0
AP Mondovi	20	0.0	0.0	0.0		57.5	57.6	0.1		101.9	97.7	-4.3		-4.4	-4.2	-91.1	0
Ryan	21	0.9	0.0	0.9		58.6	58.7	0.0		113.2	114.2	1.0		0.9	0.9	17.9	0
SY Gunsight	22	0.0	0.0	0.0		58.4	57.9	-0.5		97.6	93.5	-4.1		-4.4	-4.2	-92.4	0
Seahawk	23	0.0	0.0	0.0		58.6	58.9	0.3		93.3	92.2	-1.1		-1.2	-1.2	-25.5	0
Alum	24	0.3	0.0	0.3		59.6	59.6	0.0		89.8	90.5	0.7		0.7	0.7	15.0	0
Mean		6.6	0.0	6.5		58.6	58.8	0.2		87.3	87.0	-0.2		-0.3	-0.3	-5.7	
Mean (excl.PS279)		*2.5*	*0.0*	*2.5*		*58.7*	*58.9*	*0.2*		*87.8*	*87.4*	*-0.4*		*-0.4*	*-0.2*	*-8.8*	
R^2		**0.9**				**0.6**				**0.8**							
CV		**145.6**				**1.4**				**7.1**							
***p*-value**		**<0.0001**				**<0.0001**				**<0.0001**							
LSD (*P* = 0.05)		**6.7**				**1.1**				**8.7**							

[a] Quilt Xcel at 14.0 fl oz/A was sprayed first time at early jointing stage (Feekes 4-5) on 7 June when stripe rust was absent in the field, and second time on 21 June when plants were atflag-boot stage (Feekes 9-10) and the non-first spray AvS plots had 0-0.1% stripe 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 $P \leq 0.05$.

B. Fungicide tests in 2023

In 2023, 19 fungicide treatments, plus a non-treated check, were evaluated for stripe rust control efficacy on a susceptible winter wheat variety (PS279) on the PCFS Farm near Pullman. This experiment was conducted using the complete randomized block design, just next to the winter wheat variety yield loss experiment. The stripe rust inoculation and data collection were the same as described above. The average stripe rust severity values at each data collection point, as well as rAUDPC, test weight, and yield, for each treatment are shown in **Table 3**.

All the fungicide treatments significantly reduced stripe rust rAUDPC and increased grain test weight and yield. The yield increases ranged from 26.2% by Tilt (4.0 fl oz/A applied at Feekes 5) to 43% by a new fungicide (ADM.03509.F.3.B) applied at 12 fl oz/A at both Feekes 5 and Feekes 10. These results can be used to select fungicides and application timing based on the pattern and level of stripe rust development.

The fungicide treatments were also tested on a susceptible spring wheat variety (AvS). Due to the low level and nonuniformity of stripe rust, the efficacies of the treatments were not distinguishable.

Table 3. Summary of fungicide treatments for control of stripe rust on susceptible winter wheat (PS279) tested in artificially inoculated field near Pullman, WA in 2023

		Stripe rust severity (%)[d]												Test		Yield		
Treatment		18 May		24 May		5 Jun		15 Jun		20 Jun		Relative		weight[d]		Mean[d]		Increase
No.	Fungicide, rate, timing[a,b,c]	E. jointing		L. jointing		Boot		Heading		Flowering		AUDPC		(lb/bu)		(bu/A)		%
1	No fungicide	0.10	A	0.8	A	31.3	A	90.0	A	95.8	A	100.0	A	55.5	F	66.1	E	0.0
2	Miravis Ace 7.0 fl oz/A at Fks 5; Trivapro 13.7 fl oz/A at Fks 10	0.10	A	1.0	A	2.5	CD	2.3	EF	3.0	F	4.8	EF	61.6	A-C	99.3	B-D	33.4
3	Miravis Ace 7.0 fl oz/A + Tilt 2.0 fl oz/A at Fks 5; Trivapro 13.7 fl oz/A at Fks 10	0.10	A	1.0	A	2.0	CD	2.0	F	2.8	F	4.2	EF	61.4	A-D	101.2	A-D	34.7
4	Aprovia Ace 9.4 fl oz/A at Fks 5; Aprovia Ace 9.4 fl oz/A at Fks 10	0.10	A	1.3	A	1.3	CD	1.3	F	1.8	F	3.1	EF	62.0	A	99.3	B-D	33.4
5	Aprovia Ace 9.4 fl oz/A at Fks 5; Trivapro 13.7 fl oz/A at Fks 10	0.05	AB	1.3	A	1.3	CD	1.3	F	1.5	F	3.1	EF	61.2	A-E	100.9	A-D	34.5
6	Trivapro 7.0 fl oz/A at Fks 5; Aprovia Ace 9.4 fl oz/A at Fks 10	0.10	A	1.0	A	1.0	D	1.0	F	1.8	F	2.6	EF	61.8	AB	101.6	A-D	35.0
7	ADM.03509.F.3.B 8.0 fl oz/A at Fks 5; ADM.03509.F.3.B 8.0 fl oz/A at Fks 10	0.10	A	1.0	A	1.0	D	1.0	F	2.8	F	2.8	EF	61.6	A-C	104.8	A-D	36.9
8	ADM.03509.F.3.B 12.0 fl oz/A at Fks 5; ADM.03509.F.3.B 12.0 fl oz/A at Fks 10	0.08	AB	0.8	A	1.0	D	1.0	F	1.5	F	2.3	F	61.3	A-E	112.1	AB	41.0
9	ADM.03509.F.3.B 16.0 fl oz/A at Fks 5; ADM.03509.F.3.B 16.0 fl oz/A at Fks 10	0.05	AB	1.0	A	1.3	CD	1.3	F	1.3	F	2.8	EF	61.4	A-D	116.4	A	43.2
10	CUSTODIA 6.8 fl oz/A at Fks 5; CUSTODIA 6.8 fl oz/A at Fks 10	0.10	A	0.8	A	3.5	C	2.3	EF	2.0	F	5.4	EF	61.6	A-B	106.3	A-D	37.8
11	MATTOCK 6.8 fl oz/A at Fks 5; MATTOCK 6.8 fl oz/A at Fks 10	0.08	AB	0.8	A	2.3	CD	1.5	F	2.3	F	3.9	EF	60.9	A-E	104.8	A-D	36.9
12	QUILT XCEL 7.5 fl oz/A at Fks 5; QUILT XCEL 7.5 fl oz/A at Fks 10	0.03	B	1.0	A	1.3	CD	1.3	F	1.8	F	2.9	EF	60.7	B-E	108.9	A-C	39.3
13	Tilt 4.0 fl oz/A at Fks 5	0.05	AB	0.8	A	1.0	D	5.0	EF	12.0	E	6.8	EF	60.2	DE	89.6	D	26.2
14	Quilt Xcel 14 fl oz/A at Fks 5	0.10	A	1.0	A	1.0	D	4.5	EF	11.3	E	6.5	EF	60.3	C-E	104.8	A-D	36.9
15	Trivapro 7.0 fl oz/A at Fks 5	0.10	A	1.0	A	1.0	D	6.3	E	12.5	E	7.8	E	60.0	E	110.2	A-C	40.0
16	Tilt 4.0 fl oz/A at Fks 10	0.08	AB	1.0	A	31.3	A	38.8	B	45.0	B	59.8	B	61.0	A-E	94.7	CD	30.2
17	Tilt 4.0 fl oz/A at Fks 5; Quilt Xcel 14.0 fl oz/A at Fks 10	0.10	A	1.0	A	1.3	CD	1.3	F	2.0	F	3.0	EF	61.8	AB	103.5	A-D	36.1
18	Trivapro 13.7 fl oz/A at Fks 10	0.08	AB	1.0	A	25.0	B	25.0	D	27.5	D	42.7	D	61.7	AB	104.3	A-D	36.6
19	Quilt Xcel 14.0 fl oz/A at Fks 10	0.10	A	1.0	A	30.0	A	32.5	C	36.3	C	53.2	C	60.9	A-E	94.5	CD	30.1
20	Tilt 4 fl oz/A at Fks 5; Tilt 4.0 fl oz/A at Fks 10	0.08	AB	0.8	A	1.5	CD	1.3	F	1.8	F	3.0	EF	60.6	B-E	104.6	A-D	36.8
	R^2	0.35		0.1		1.0		1.0		1.0		1.0		0.7		0.5		
	CV	42.85		44.0		25.0		26.4		34.5		23.9		1.5		11.7		
	p-value	0.06		0.968		<0.0001		<0.0001		<0.0001		<0.0001		<0.0001		<0.0005		
	LSD ($P \leq 0.05$)	0.05		0.59		2.50		4.11		6.5		5.41		1.31		16.75		

[a] The application at Feekes 5 (early jointing) was done on 25 May, and at Feekes 10 (boot) on 6 June, 2023.
[b] The field was under inoculation of the wheat stripe rust pathogen.
[c] In treatments 2-6 and 12-20, 0.25% v/v NIS was included in each application.
[d] Means sharing one or more letters are not significantly different at $P = 0.05$.

C. Fall stripe rust survey

On November 14, we were checking wheat fields in Whitman, Adams, Lincoln, Douglas, and Grant counties in eastern Washington. Ranging from just emerged (Feekes 1) to early jointing (Feekes 5), winter wheat generally had good emergency. We checked over 30 fields with big plants (Feekes 3-5) and found stripe rust in only one field along Highway 2 in Lincoln County (**Figure 1**). Although the incidence of stripe rust was below 0.1 percent, stripe rust was quite easy to find with two to four leaves infected in some spots. This is the first to see stripe rust infection in the fall after 2018. The infection level was higher than that in the fall of 2018 but lower than that in the fall of 2016.

Whether the stripe rust pathogen can survive the winter in the infected plants will depend upon how cold this winter will be. Based on the forecast of above-normal temperatures of this winter, the stripe rust will likely overwinter and spark stripe rust in the coming spring. We will make stripe rust forecasts in January and March based on the winter weather data and check fields in late February or early March.

Figure 1. Stripe rust observed in a winter wheat field along Highway 2 in Lincoln County, Washington on November 14, 2023.