WHEAT (*Triticum aestivum*)
Stripe rust; *Puccinia striiformis* f. sp. *tritici*

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Evaluation of winter wheat cultivars to fungicide application for control of stripe rust in 2016.

A study was conducted in a field near Pullman, WA to evaluate the control of stripe rust with fungicide applications on winter wheat cultivars and assess yield loss caused by the disease. Ammonium nitrogen fertilizer was applied at 100 lb/A at the time of planting. Winter wheat genotype 'PS 279' was used as a susceptible check and 23 cultivars were selected based on their acreage planted in the state of Washington in 2015 or new releases. The 24 entries were arranged in a randomized split block design based on fungicide application, with four replications. They were seeded in rows spaced 14-in. apart at 60 lb/A (99% germination rate) with a drill planter on 20 Oct 15. The plots were 4.5 ft in width and 14.0 to16.4 ft in length. Herbicides (Huskie 15.0 fl oz/A + Axial XL 16.4 fl oz/A + M-90 10.4 fl oz/A) were applied on 22 Apr when wheat plants were at the early jointing stage (Feekes 4). On 10 May when most plants were at the early jointing stage (Feekes 5) Quilt 1.66SE, was sprayed at the rate of 14.0 fl oz/A mixed with M-90 at the rate of 14.0 fl oz/A in 16 gallon water/A and stripe rust had started developing on the susceptible check PS 279 plants (3-5% severity). On 7 Jun (28 days after the first application) when the plants were at the flowering stage (Feekes 10.5) a second fungicide application was applied at the same rate and stripe rust reached 100% severity in the non-treated susceptible check plots. A 601C backpack sprayer was used with a CO_2-pressurized spray boom at 18 psi having three operating ¼ in. nozzles spaced 19-in. apart. Disease severity (percentage of diseased foliage per whole plot) was assessed from each plot on 10 May at the early jointing stage, 23 May at the boot stage, 7 Jun at the flowering stage, and 20 Jun at the soft dough stage or 0, 13, 28, and 41 days after the first fungicide application. Plots were harvested on 16 Aug when kernels had 3 to 5% kernel moisture and test weight of kernels was measured. Area under the disease progress curve (AUDPC) was calculated for each plot using the three sets of severity data. Relative AUDPC (rAUDPC) was calculated as percent of the non-treated control. rAUDPC, test weight, and yield data were subjected to analysis of variance, and the effect of fungicide application on rAUDPC reduction and test weight and yield increases for each cultivar was determined by Fisher's protected LSD test.

A natural infection of stripe rust was first observed on PS 279 in late April, approximately two weeks earlier than normal for the area. The disease reached 80% severity in the non-sprayed susceptible check plots on 23 May (boot stage), 13 days after the fungicide was first applied, and 100% on 7 Jun (flowering stage) in the plots of the susceptible check without fungicide application. The two applications of Quilt at 14 fl oz/A did not completely prevent stripe rust infection, mainly due to the fact that the second application was later than the optimal timing as disease severity reached 80% when the second application was made. However, the fungicide applications significantly reduced the rAUDPC for the susceptible check, but the reduction was only 43%. The fungicide applications also significantly reduced rAUDPC for cultivars Xerpha, Eltan, ORCL-103, ORCF-102, Whetstone, Keldin, ARS-Crescent, Westbred 528, Puma, ARS-Crystal, Jasper, and WB 523, but the reductions were not significant for the remaining 11 cultivars with greater levels of resistance as rust severity was low in both non-sprayed and sprayed plots. The fungicide applications significantly increased grain test weight of the susceptible check (PS 279) and cultivars Xerpha, Eltan, ORCF-103, ORCF-102 and ARS-Crystal by 1.8 to 5.0 lb/bu. The affect of fungicide applications on yield ranged from -6.6 (-4.5%) to 66.2 bu/A (249.0%) in the 24 entries, but significant yield increases were only observed for the susceptible check and five cultivars (Xerpha, Eltan, ORCF-103, ORCF-102, and WB-Arrowhead). These data indicate stripe rust caused yield loss of 66.2 bu/A (71.4%) on the susceptible check and 8% yield loss on average across the commercially grown cultivars, excluding the susceptible check. This study indicated that under the severe stripe rust epidemic in 2016, most winter wheat cultivars had adequate levels of resistance and about 20% of the cultivars needed at least two applications of effective fungicides. Timing of fungicide applications was also important.

	rAUDPC (%)[y]			Test weight (lb/bu)[x]			Yield (bu/A)[x]		
Wheat cultivar[z]	No spray	Spray[w]	Reduction[v]	No spray	Spray[w]	Increase[v]	No spray	Spray[w]	Increase[v]
PS 279	100.0	57.1	43.0*[u]	53.6	58.6	5.0*[u]	26.6	92.7	66.2*[u]
Xerpha	37.2	20.5	16.6*	58.3	60.0	1.8*	98.5	145.1	46.6*
Eltan	32.3	12.1	20.2*	56.2	59.0	2.8*	108.3	145.3	37.0*
ORCF-103	34.3	15.5	18.8*	56.7	58.7	2.0*	124.2	166.2	42.0*
ORCF-102	29.1	17.7	11.4*	57.5	60.4	2.9*	114.0	145.6	31.6*
WB-Arrowhead	5.1	2.7	2.4	62.0	62.3	0.3	121.4	137.0	15.6*
Whetstone	11.4	5.5	6.0*	61.7	62.7	1.0	107.1	119.5	12.4
Keldin	21.6	6.1	15.5*	61.8	62.5	0.6	123.8	137.0	13.3
Farnum	4.3	3.0	1.3	59.6	59.8	0.3	108.9	119.2	10.3
ARS-Crescent	17.4	10.9	6.5*	57.9	57.8	- 0.1	145.7	157.6	12.0
Westbred 528	7.8	3.1	4.7*	60.6	60.8	0.2	127.7	137.2	9.5
Puma	21.0	11.6	9.4*	58.1	58.7	0.6	146.9	155.4	8.5
ARS-Crystal	18.5	8.0	10.5*	57.7	59.6	1.9*	135.2	142.3	7.1
Otto	7.2	3.6	3.6	59.8	60.4	0.5	137.2	144.0	6.7
Jasper	14.2	6.0	8.2*	59.0	59.2	0.2	155.2	162.8	7.5
Madsen	7.3	7.2	0.1	60.0	59.6	-0.4	148.2	154.4	6.2
Cara	2.1	1.8	0.3	56.9	57.3	0.4	139.1	143.6	4.5
AP700CL	7.4	4.3	3.1	60.1	60.0	-0.1	153.9	156.0	2.1
ARS-Selbu	5.8	4.0	1.8	61.3	61.3	0.0	143.7	145.5	1.8
Norwest 553	10.3	8.6	1.6	62.2	62.4	0.1	130.4	131.7	1.3
Bruehl	8.0	5.6	2.4	57.7	58.0	0.3	143.2	144.1	1.0
WB 523	12.3	4.8	7.5*	59.9	59.9	0.0	146.2	146.4	0.2
Skiles	8.0	5.6	2.4	59.8	59.7	-0.2	133.5	131.9	-1.6
LCS-Azimut	4.2	2.7	1.5	58.0	58.0	0.0	146.6	140.0	-6.6
R^2	1.0			0.9			0.9		
CV	23.1			1.6			7.9		
P-value	<0.0001			<0.0001			<0.0001		
LSD ($P \leq 0.05$)	4.4			1.3			14.8		

[z] Wheat genotype PS 279 was used as a susceptible check, and the remaining 23 cultivars were selected based on their planted acreage in the State of Washington in 2015, which were also major cultivars planted in Idaho and Oregon.

[y] AUDPC is area under disease progress curve, = ∑[rust severity (i) + rust severity (i+1)]/2*days, calculated using severity data recorded four times at early jointing stage (10 May), boot stage (23 May), flowering (7 Jun), and soft dough stage (20 Jun). Stripe rust severity was recorded as percentage of whole plot leaf area with disease. Relative AUDPC (rAUDPC) was calculated for each treatment as the percent of the AUDPC (as 100%) of the susceptible check without fungicide application.

[x] Test weight (lb/bu) and yield (bu/A) based on 3 to 5% kernel moisture.

[w] Fungicide, Quilt 1.66 SE, was sprayed at the rate of 14.0 fl oz/A mixed with surfactant M-90 at the rate of 14.0 fl oz/A on 10 May when the plants were at the early jointing stage (Feekes 5) and stripe rust started developing on the susceptible check PS 279 plants (3-5% severity) and sprayed again at the same rate on 7 Jun (28 days after the first application) when the plants were at the flowering stage (Feekes 10.5) and stripe rust reached 100% severity in the non-treated susceptible check plots.

[v] The reduction value of rAUDPC (%) was calculated by subtracting the mean of the sprayed plots from the mean of the non-sprayed plots for each cultivar, and the increase value of test weight (lb/bu) or yield (bu/A) was calculated by subtracting the mean of non-sprayed plots from the mean of the sprayed plots for each cultivar as the benefits of the fungicide application.

[u] The "*" indicates that the value is significant at $P = 0.05$ as determined by LSD test.