

Control of stripe rust of spring wheat with foliar fungicides in 2016.

The study was conducted in a field with Palouse silt loam soil near Pullman, WA. Stripe rust susceptible 'Avocet S' spring wheat was seeded in rows spaced 14-in. apart at 60 lb/A with a drill planter on 4 May 2016. Urea fertilizer (46-0-0) was applied at the rate of 100 lb/A on 27 May when wheat plants were at the tillering stage (Feekes 2). Herbicides (Huskie, 15 fl oz/A, Axial XL, 16.4 fl oz/A, and M-90, 10.4 fl oz/A) were applied to the entire field to control weeds on 31 May when wheat plants were at the tillering stage (Feekes 3). Before the first fungicide application, the field was divided into individual plots of 4.5 ft (4 rows) in width and 15.2 to 16.8 ft in length by eliminating plants between plots by spraying herbicide (Glystar, 3.4 fl oz/gal + M90 3.4 fl oz/gal) on 6 Jun. Fungicides were applied in 16 gal water/A on different dates and stages depending upon the treatment. The first fungicide application timing at the early jointing stage (Feekes 4) was made on 7 Jun when stripe rust was 2 to 10% severity in the field. The second application was done at the flag leaf stage (Feekes 8) on 22 Jun when stripe rust in the plots without first fungicide application reached 40-50% severity. The third application was done at the boot stage (Feekes 10.) on 1 Jul when stripe rust in the plots without previous fungicide applications reached 90-95% severity. A 601C backpack sprayer was used with a CO₂-pressurized spray boom at 18 psi having three operating 0.25-in. nozzles spaced 19-in. apart. A randomized complete block design was used with four replications. Disease severity (percentage of diseased foliage per whole plot) was assessed from each plot on 8 Jun, 15 Jun, 30 Jun, 10 Jul (data not presented), and 18 Jul or 1, 8, 23, 33, and 41 days after the first fungicide application timing, respectively. Plots were harvested on 22 Aug when kernels had 3 to 5% kernel moisture and test weight of kernels was measured. Area under disease progress curve (AUDPC) was calculated for each plot using the five sets of severity data. Relative AUDPC (rAUDPC) was calculated as percent of the non-treated check. Rust severity, rAUDPC, test weight, and yield data were subjected to analysis of variance and means were separated by Fisher's protected LSD test.

Stripe rust started developing in the plots in late May when plants were at the tillering stage (Feekes 2-3) and reached 90% and 100% severity at the flowering and milk stages, respectively in the non-treated check plots. All fungicide treatments with the application at the early jointing stage (Feekes 4) significantly reduced rust severity compared to the non-treated check. Treatments without the first application at the boot stage, and all treatments with only the first application did not significantly reduce rust severity compared to the non-treated check when evaluated at the milk (data not presented) and soft dough stages. The rAUDPC values of all treatments were significantly less than the non-treated check, except the treatment A21573A 11.4 fl oz/A applied at Feekes 10. Four treatments, Trivapro 9.4 fl oz/A applied at Feekes 4 followed by Trivapro 13.7 fl oz/A at Feekes 8, Quilt Xcel 7.0 fl oz/A at Feekes 4 followed by Trivapro 13.7 fl oz/A at Feekes 8, Trivapro 9.4 fl oz/A applied at Feekes 4 followed by Quilt Xcel 10.5 fl oz/A at Feekes 8, and Quilt Xcel 7.0 fl oz applied at Feekes 4 followed by Quilt Xcel 10.5 fl oz/A at Feekes 8, provided the best control of stripe rust and also produced the highest yields. Significant differences in grain test weight were observed among the fungicide treatments. The test weights from treatments of only the first application were similar to that of non-treated check; and those of treatments with the later application were significantly higher than that of the non-treated check, except treatments of OR 009F-1-A or OR 097F-3 at various rates plus UAN-32 64 fl oz/A and Tilt 4.0 fl oz/A plus UAN-32 64 fl oz/A applied at Feekes 8 without M90. Except treatments of Topguard 3.0 fl oz/A applied at Feekes 4 and various rates of OR 009F-1-A or OR 097F-3 plus UAN-32 64 fl oz/A applied at Feekes 8, all other treatments significantly preserved yield compared to the non-treated check. The significant increases of grain yield ranged from 8 bushels (65%) by the treatment of Priaxor 2.0 fl oz applied at Feekes 4 to 56 bushels (449%) by the treatment of Trivapro 9.4 fl oz/A applied at Feekes 4 followed by Trivapro 13.7 fl oz/A applied at Feekes 8.

Treatment, rate/A	Growth stage ^y (Feekes)	Stripe rust severity (%) ^z				Relative AUDPC ^x	Test weight ^w (lb/bu)	Yield ^w (bu/A)
		8 Jun Jointing	15 Jun Boot	30 Jun Flowering	18 Jul dough			
Non-treated	---	3.5 a-c ^y	17.5 ab	90.0 a	100.0 a	100.0 a	53.1 i-m	12.4 v
Topguard 1.04SC, 3.0 fl oz	4	3.5 a-c	3.5 fg	40.0 cd	100.0 a	70.4 c-e	50.7 lm	16.9 t-v
Priaxor 4.17SC, 2.0 fl oz ¹	4	2.8 a-c	2.8 fg	12.5 h-l	100.0 a	56.9 fg	51.3 k-m	20.6 q-u
Topguard 1.04SC, 6.0 fl oz ^s	4	2.3 bc	4.3 fg	25.0 e	100.0 a	62.6 e-g	52.4 i-m	21.6 p-t
Tilt 3.6EC, 4.0 fl oz ¹	4	4.3 ab	3.5 fg	20.0 e-h	100.0 a	60.1 fg	50.5 m	21.8 p-t
Preemptor 3.22SC, 3.0 fl oz	4	2.8 b	3.5 fg	22.5 e-g	100.0 a	61.1 fg	52.2 i-m	22.7 p-t
Alto 100SL, 3.0 fl oz ¹	4	2.8 a-c	2.8 fg	15.0 g-k	100.0 a	57.2 fg	50.8 lm	23.3 p-s
Folicur 3.6F, 4.0 fl oz ¹	4	3.5 a-c	2.8 fg	11.3 h-m	100.0 a	55.1 g	50.5 lm	24.0 p-r
Trivapro 2.2SE, 9.4 fl oz ¹	4	2.8 a-c	3.5 fg	18.8 e-i	98.8 a	58.7 fg	52.1 j-m	25.3 pq
Tilt 3.6EC, 4.0 fl oz ¹ + Priaxor 4.17SC, 2.0 fl oz ¹	4	2.0 c	2.8 fg	22.5 e-g	100.0 a	61.1 fg	52.0 j-m	26.0 o-q
Alto 100SL, 4.0 fl oz ¹	4	2.8 a-c	3.5 fg	23.8 ef	98.8 a	61.1 fg	51.5 k-m	26.7 o-q
Quilt Xcel 2.2SE, 7.0 fl oz ¹	4	2.8 a-c	2.0 g	16.3 f-j	100.0 a	56.2 fg	52.3 i-m	26.9 o-q
Trivapro 2.2SE, 13.7 fl oz ¹	4	2.8 a-c	3.5 fg	15.0 g-k	98.8 a	56.5 fg	52.6 i-m	27.9 n-p
OR 009F-1-A 50 fl oz/100 gal + UAN-32 64 fl oz	8	4.8 a	20.0 a	52.5 b	100.0 a	83.4 b	53.8 i-k	14.0 v
OR 009F-1-A 100 fl oz/100 gal + UAN-32 64 fl oz	8	3.5 a-c	14.3 a-d	50.0 b	100.0 a	78.8 bc	54.9 g-i	14.7 uv
OR 097F-3 50 fl oz/100 gal + UAN-32 64 fl oz	8	3.8 a-c	15.0 a-c	20.0 e-h	100.0 a	64.0 d-g	52.5 i-m	16.9 t-v
OR 097F-3 100 fl oz/100 gal + UAN-32 64 fl oz	8	3.5 a-c	17.5 ab	47.5 bc	100.0 a	78.1 bc	53.3 i-l	17.8 s-v
OR 097F-3 25 fl oz/100 gal + UAN-32 64 fl oz	8	2.8 a-c	12.5 a-f	26.3 e	100.0 a	65.4 d-f	52.6 i-m	18.1 r-v
OR 009F-1-A 25 fl oz/100 gal + UAN-32 64 fl oz	8	3.5 a-c	13.8 ab	38.8 d	100.0 a	73.2 cd	54.4 h-j	18.6 r-v
Preemptor 3.22SC, 6.0 fl oz	8	3.5 a-c	13.8 a-e	10.0 j-n	32.5 b	24.0 ij	60.2 a-d	32.2 no
OR 009F-1-B 25 fl oz/100 gal + UAN-32 64 fl oz	8	2.8 a-c	13.8 a-e	7.5 k-o	20.0 c-g	16.2 j-q	60.9 ab	39.7 lm
Topguard 1.04SC, 6.0 fl oz	8	4.3 ab	20.0 a	8.8 j-o	27.5 b-d	25.8 i	60.1 a-d	40.7 kl
Tilt 3.6EC, 4.0 fl oz + OR 009F-1-B 25 fl oz/100 gal + UAN-32 64 fl oz	8	3.5 a-c	11.3 a-g	8.8 j-o	32.5 b	20.7 i-l	58.4 b-f	41.0 j-l
Tilt 3.6EC, 4.0 fl oz + OR 009F-1-B 100 fl oz/100 gal + UAN-32 64 fl oz	8	3.5 a-c	13.8 a-e	11.3 h-m	23.8 b-f	20.3 i-m	59.3 a-f	42.1 i-l
Tilt 3.6EC, 4.0 fl oz + OR 009F-1-B 50 fl oz/100 gal + UAN-32 64 fl oz	8	3.5 a-c	15.0 a-c	8.8 j-o	23.8 b-f	19.6 i-m	59.2 a-f	43.3 i-l
Topguard 1.04SC, 10.0 fl oz	8	2.0 c	12.5 a-f	10.0 j-n	21.3 b-g	20.3 i-m	59.8 a-e	43.6 h-l
Tilt 3.6EC, 4.0 fl oz + M-90 16 fl oz/100 gal + UAN-32 64 fl oz	8	2.0 c	10.0 b-g	7.5 k-o	25.0 b-e	16.5 j-q	59.8 a-e	43.9 h-l
A21573A 125/150SE 11.4 fl oz ¹	8	2.8 a-c	11.3 a-g	7.5 k-o	30.0 bc	23.5 ij	59.2 a-f	45.2 h-l
Twinline 210EC, 7.0 fl oz ¹	8	2.5 bc	13.8 a-e	7.5 k-o	20.0 c-g	17.4 i-p	61.5 a	46.7 h-k
A21461A 300SE, 10.3 fl oz ¹	8	4.3 ab	20.0 a	7.5 k-o	23.8 b-f	22.1 i-k	59.8 a-e	53.2 e-g
Trivapro 2.2SE, 13.7 fl oz ¹	8	4.0 a-c	17.5 ab	5.0 l-o	18.8 c-g	17.4 i-p	59.7 a-f	55.2 d-f
Twinline 210EC, 9.0 fl oz	8	3.5 a-c	12.5 a-f	7.5 k-o	20.0 c-g	17.4 i-p	60.0 a-e	58.3 c-e
A21461A 300SE, 13.7 fl oz ¹	8	4.3 ab	15.0 a-c	5.5 l-o	16.3 d-h	14.1 k-r	60.1 a-d	58.3 c-e
Tilt 3.6EC, 4.0 fl oz + UAN-32 64 fl oz	8	4.3 ab	5.0 d-g	3.5 m-o	27.5 b-d	11.5 l-r	54.9 g-i	61.0 b-d
A21573A 125/150SE 11.4 fl oz ¹	10	3.0 a-c	12.5 a-f	91.3 a	90.0 a	95.6 a	60.1 a-d	23.0 p-t
Preemptor 3.22SC, 3.0 fl oz fb ^u Preemptor 3.22SC, 6.0 fl oz	4 fb ^u 8	3.5 a-c	3.5 fg	4.3 m-o	32.5 b	18.3 i-n	57.0 f-h	49.7 f-h
Tilt 3.6EC, 2.0 fl oz ¹ + Priaxor 4.17SC, 2.0 fl oz ¹ fb Priaxor 4.17SC, 4.0 fl oz ¹	4 fb 8	2.8 a-c	3.5 fg	3.5 m-o	26.3 b-e	15.2 j-q	57.6 d-g	56.3 de
Topguard 1.04SC, 3.0 fl oz fb Topguard 1.04SC, 10.0 fl oz	4 fb 8	2.8 a-c	3.5 fg	2.8 no	15.0 e-h	8.9 o-r	57.7 d-f	58.5 c-e
Trivapro 2.2SE, 9.4 fl oz ¹ fb Quilt Xcel 2.2SE, 10.5 fl oz ¹	4 fb 8	2.8 a-c	2.8 fg	1.5 o	15.0 e-h	8.4 p-r	58.4 b-f	62.8 a-c
Quilt Xcel 2.2SE, 7.0 fl oz ¹ fb Trivapro 2.2SE, 13.7 fl oz ¹	4 fb 8	2.8 a-c	2.8 fg	1.8 o	15.0 e-h	8.1 qr	57.9 c-f	64.6 a-c
Quilt Xcel 2.2SE, 7.0 fl oz ¹ fb Quilt Xcel 2.2SE, 10.5 fl oz ¹	4 fb 8	2.0 c	2.0 g	1.3 o	10.0 gh	5.9 qr	58.0 c-f	66.7 ab
Trivapro 2.2SE, 9.4 fl oz ¹ fb Trivapro 2.2SE, 13.7 fl oz ¹	4 fb 8	2.0 c	2.8 fg	1.3 o	17.5 d-g	9.0 o-r	57.9 c-f	68.3 a
Trivapro 2.2SE, 9.4 fl oz ¹ fb A21573A 125/150SE 11.4 fl oz ¹	4 fb 10	2.0 c	2.0 g	18.8 e-i	20.0 c-g	37.1 h	57.2 e-g	42.8 i-l
CV	---	52.0	79.3	33.2	16.0	17.5	3.5	12.1
p-value	---	0.7	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
LSD ($P \leq 0.05$)	---	2.2	9.9	8.2	12.0	9.3	2.8	6.4

^z Stripe rust severity was recorded as percentage of whole plot leaf area with disease.

^y The first application at Feekes 4 was done on 7 Jun when wheat plants were at the early jointing stage; the second application at Feekes 8 was done on 22 Jun when wheat plants were at the late jointing stage; and the last application at Feekes 10 was done on 1 Jul when wheat plants were at the boot stage.

^x AUDPC is area under the disease progress curve, = $\sum[\text{rust severity (i)} + \text{rust severity (i+1)}]/2 * \text{days}$. Relative AUDPC was calculated for each treatment as the percent of the AUDPC (as 100%) of the nontreated.

^w Test weight (lb/bu) and yield (bu/A) based on 3 to 5% kernel moisture.

^v Column numbers followed by the same letter are not significantly different at $P = 0.05$ as determined by LSD test.

^u fb, followed by.

^t Crop oil concentrate (COC) SL 1% v/v mixed with the fungicide.