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The Biology and Control of the Septoria Diseases of Winter Wheat in Western Oregon

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The biology and control of the septoria diseases of winter wheat in western Oregon.

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The septoria diseases of winter wheat are a limiting factor to wheat production in the Willamette Valley. This publication will describe the symptoms and development of the septoria diseases, including the influence of environmental conditions, the reactions of different cultivars to *Septoria*, the impact of *Septoria* on yield, and control methods.

Disease symptoms

There are three septoria diseases that can occur in western Oregon. *Septoria tritici*, causal agent of septoria tritici blotch, is the most common of the three. *Septoria nodorum,* causal agent of septoria nodorum blotch, was not common in the past, but is increasing in importance. *Septoria avenae* is present in Oregon, but does not cause serious disease epidemics. The information in this publication pertains only to *Septoria tritici* and *Septoria nodorum*.

The disease symptoms of *Septoria tritici* and *Septoria nodorum* are very similar. It is difficult to tell the two diseases apart without the use of a hand lens or a dissecting microscope. The initial symptoms of both *Septoria tritici* and *Septoria nodorum* are yellow flecks on the lower leaves of the plant. These flecks are found very early in the season and eventually develop into lesions. *Septoria tritici* lesions are rectangular and follow the leaf veins. The lesion is brown and when mature contains tiny dark brown or black spot-like structures called pycnidia. *Septoria tritici* can infect all parts of the plant, but does not usually infect the seed. Lesions on the head are sunken and light tan with black pycnidia.

The lesions of *Septoria nodorum* are lens-shaped and brown with yellow edges. The lesions may have a darker brown center. The pycnidia of *Septoria nodorum* are more difficult to see. When visible, the pycnidia are golden brown in color. When head infections occur, *Septoria nodorum* may infect the seed. Head lesions are dark brown and have a "crusty" appearance with raised pycnidia. Sometimes a peach-colored spore mass is visible on the pycnidia. Seed from infected heads is shrunken and wrinkled.

Lesions of both fungi may occur on the same leaf, and the lesions may overlap, making diagnosis difficult.

Disease development

The life cycles of *Septoria tritici* and *Septoria nodorum* are also very similar. These fungi survive the time between wheat crops on field residues, volunteer wheat plants, and secondary weed hosts. *Septoria nodorum* can also survive on wheat seed. Beginning in the fall, spores (ascospores) are produced and are blown by the wind onto the wheat crop. These spores cause the initial infections of the wheat crop. Our research shows that these wind-blown spores are produced throughout the growing season, even when temperatures are below freezing. Ascospore production of *Septoria tritici* peaks in the fall (November or December), while ascospore production of *Septoria nodorum* occurs in the fall (October) but is much more frequent in the spring (March) (Figure 1). Infections of wheat in the field have been observed as early as December.

After infection, a lesion forms on the wheat leaf. The time between when the spore lands, successfully germinates, and infects a leaf and the presence of a visible, sporulating lesion is called the latent period and is usually 14-21 days. These lesions produce a second type of spore (pycnidiospore) which is splashed upward by rain onto newly formed leaves and also onto other plants. These spores permit the disease to spread within the wheat field.

Environmental conditions that favor disease

The environment of the Willamette Valley is ideal for the development of the septoria diseases. Infection can occur between 41 and 95 degrees Fahrenheit. *Septoria tritici* grows best between 68 and 77 degrees. *Septoria nodorum* grows best at temperatures between 72 and 75 degrees. Epidemics are favored by wet, windy weather. In order for spores to germinate once they land on a leaf, the leaf must be wet and remain wet for at least 6 hours. The later the rains continue in the spring, the more these diseases will spread. *Septoria nodorum* increases later in the season than *Septoria tritici*.

Monitoring the septoria diseases

Septoria lesions can be found in the field in early March. The distribution of the disease is uniform, and often lesions can be found on almost every plant in a given field. The spread of disease up the plant should be monitored in relation to the developmental stage of the plant. Since the flag leaf plays a critical role in grain development, the amount of disease on the flag leaf has a large impact on yield. One indication of the potential of a septoria epidemic is the amount of disease on the three leaves below the flag leaf (F) at flag leaf emergence; e.g. leaves F-1, F-2, and F-3. In most years, there are few sporulating lesions on the F-1 leaf at flag leaf emergence, less than 50 percent of the F-2 leaves have sporulating lesions, and more than 50 percent of the F-3 leaves have sporulating lesions. This amount of disease is sufficient to reduce yield on susceptible cultivars. Often small yellow flecks are visible on the F-1 and F-2 leaves at flag leaf emergence. These flecks may develop into lesions.

Response of different cultivars

The amount of disease varies from cultivar to cultivar. Currently, there are no winter wheat cultivars grown in western Oregon that are completely resistant to both *Septoria tritici* and *Septoria nodorum*. Some cultivars show a moderate level of resistance, and some are very susceptible to the septoria diseases.

Figure 2 compares the amount of disease between years on Gene, Madsen, Malcolm, and Stephens in experiments at Corvallis. Figure 3 contains the same data from experiments at Aurora, and includes sprayed and unsprayed treatments. Table 1 contains disease assessment data from sprayed and unsprayed plots in variety trials at six different sites. For all of the tables in this publication, the year listed is the year in which the winter wheat crop was harvested. Disease assessments were taken each year at the milky ripe growth stage.

Stephens and Malcolm had the highest level of susceptibility (Figures 2 and 3). Madsen appears to be moderately resistant to the septoria diseases. The cultivar Gene is resistant to *Septoria tritici*, but is susceptible to *Septoria nodorum*. The total amount of *Septoria* on Gene is usually similar to the total amount of *Septoria* on Madsen. The 1992-1993 season produced one of the most severe septoria epidemics observed in the Willamette Valley. At Corvallis, the level of disease in unsprayed plots of Gene was almost as great as, or greater than, the levels on Stephens and Malcolm (Figure 2). At

Aurora (Figure 3), the levels of disease on unsprayed Madsen and Gene were comparable to the disease levels on Stephens and Malcolm.

Effect of disease on yield

Fungicide applications have been used to reduce septoria disease levels. Table 1 shows the percentage of disease in sprayed and unsprayed plots. Note that sprayed plots can have significant levels of infection despite the application of a fungicide. Fungicide applications can increase yields of all cultivars, but the consistency of the yield response is cultivar specific. The timing of fungicide applications is discussed in the next section. It is important to note that in these experiments all fungicide applications were applied from the ground. Results with aerial applications may differ from the results presented. The fungicide used in all of these experiments was a single application of propiconazole (Tilt) at a rate of 4 fl oz/A. Tilt is a broad spectrum, systemic fungicide. It has some curative activity, but works best when applied preventatively. Tilt can only be applied once per season and cannot be applied after Feekes growth stage 8 (flag leaf emergence). Mancozeb[1] (1.6 lb ai/A) in combination with 4 oz of Benlate 50 WP (Oregon and Washington only) is also effective at reducing septoria disease levels. Mancozeb is a protective fungicide. Benlate is a locally systemic fungicide and can act as a curative. Mancozeb and Benlate can be applied more than once per season, but they cannot be applied within 26 days of harvest.[2]

Table 2 shows the yield increase due to a fungicide spray for Gene, Madsen, and Stephens in variety trials over 13 site-years. Table 3 shows the yields of the sprayed and unsprayed plots in these variety trials. Fungicide treatments were a single application of Tilt (4 fl oz/A). Spray timing was 1-2 inches of flag leaf emerged on Stephens, late flag leaf emergence on Gene, and very early flag leaf emergence on Madsen. Stephens, a susceptible cultivar, generally shows yield increases when sprayed (Table 2). Results on the cultivars Gene and Madsen have varied from year to year, and in some years there is no economic yield advantage to applying fungicides to these cultivars. Cost effectiveness of a fungicide application was calculated using the following equation:

(Cost of fungicide application per acre ÷ Price of wheat per bushel) + 3 bu/A = Increase in yield (in bu/A) needed to pay for a fungicide application.

The cost of the fungicide application includes material and application costs. The 3 bushels are added to the calculation to account for the yield loss caused by ground application of a fungicide at flag leaf emergence. For this publication, a yield increase of 6

[1] At the time of publication, the registration of Mancozeb was under review by the EPA. The label for Mancozeb on wheat may be withdrawn in the near future.
[2] Information on the properties of Tilt was obtained from Ciba-Geigy Corporation. Information on the properties of Benlate and Mancozeb was obtained from E.I. duPont de Nemours and Co., Inc.

bu/A was necessary to pay for the cost of a fungicide application: ($15 spray cost ÷ $4.50/bu wheat price) + 3 bushels = 6.33 bushels.

Gene was the least responsive, but a fungicide application was still cost effective in 8 of the 13 years (Table 2). Fungicide applications were effective in 11 out of 13 years for Stephens. In terms of yield increase, Stephens was the most responsive (average of +17 bushels), while Gene and Madsen were similar in their response (average of +9 and +10 bushels, respectively). On average, Gene and Madsen gave similar yields, and yields for both cultivars exceeded the yield of Stephens, especially when no fungicide was applied (Table 3).

Table 4 compares test weight data from sprayed and unsprayed plots. In most cases, the sprayed plots have higher test weights than the unsprayed plots, but usually the increase is not very great.

Timing of fungicide application

The timing of fungicide applications is crucial to achieving disease control. For some cultivars, one spray at early flag leaf emergence will increase yield sufficiently to pay for the cost of the spray. The advantage of applying a fungicide will vary from cultivar to cultivar and from season to season. The later the first spray application, the less likely it will increase yield significantly. Some fungicides can be applied a second time at flowering, but in most seasons this is not necessary and will not give an economic yield return. The data for the fungicide timing trial are presented in Table 5.

The 1994-95 fungicide timing trial included the cultivars Gene, Madsen, and Stephens. Unsprayed plots were included for each cultivar. For the cultivar Gene, there were four single spray treatments: sprays applied at early flag, mid-flag, late flag, and flowering. There were three double spray treatments: early flag and flowering, mid flag and flowering, and full flag and flowering. Early flag sprays were applied when 1-2 inches of flag leaf was visible, mid-flag sprays were applied when half of the flag leaf was visible, and late flag leaf sprays were applied when the entire flag leaf had emerged. Tilt at a rate of 4 oz/A was used for all flag leaf spray applications. Benlate/Mancozeb (4 oz/A Benlate 50 WP and 1.6 lb ai/A Mancozeb) was used for the applications applied at flowering. On Gene, the unsprayed plots and the plots sprayed only at flowering had the highest levels of disease. All three flag spray treatments (early, mid, and late) had similar amounts of disease. The early flag and flowering treatment did not result in less disease than a single spray at early flag leaf emergence. The mid flag and flowering and the late flag and flowering treatments had the lowest levels of disease, but this disease reduction did not result in higher yields. None of the spray treatments resulted in significantly higher yields as compared to the unsprayed control.

Only one of the spray treatments, the late flag treatment on Gene, resulted in a 6 bu/A yield increase, which would pay for the cost of the spray. None of the other spray treatments applied to Gene, and none of the spray treatments applied to Madsen and Stephens, would have paid for themselves. The data from the fungicide timing trial indicate that the best time to apply a fungicide to the cultivar Gene is at late flag leaf emergence. The 1994-1995 season had less disease than average. This trial will be repeated to determine if the results will be the same in a season with more disease.

Summary

Decisions regarding the management of the septoria diseases are influenced by three factors: the cultivar grown, the level of disease in the field, and the weather. In most years, there is an economic yield advantage to applying a fungicide to the cultivar Stephens. For the cultivars Madsen and Gene, the decision is more difficult. Both cultivars have some resistance to the septoria diseases; Madsen is moderately resistant to both *Septoria tritici* and *Septoria nodorum*, and Gene is resistant to *Septoria tritici*. For these two cultivars, it is especially important to monitor disease levels during the season, particularly at or just prior to flag leaf emergence, in order to determine the level of infection prior to spraying. It may be helpful to calculate the number of bushels of yield increase needed to pay for a fungicide application. For all three cultivars, it is important that if a fungicide application is made, that it is made during flag leaf emergence. The unknown factor in this decision-making process is the weather. Without the ability to accurately predict the weather, we cannot accurately predict how severe an epidemic of septoria will be. In general, the septoria diseases are favored by wet weather. If the wet weather in any given season continues through flag leaf emergence, it is more likely that the septoria diseases will have an impact on yield.

This publication will be updated yearly to incorporate new information on the usefulness and timing of fungicide applications, and on monitoring disease progress in order to determine the necessity of fungicide applications. Questions on the information presented here should be directed to Julie DiLeone, 541-737-3557 or dileonej@bcc.orst.edu.

Fig. 1 Septoria lesions on trap plants, Corvallis, 1992-1993 season

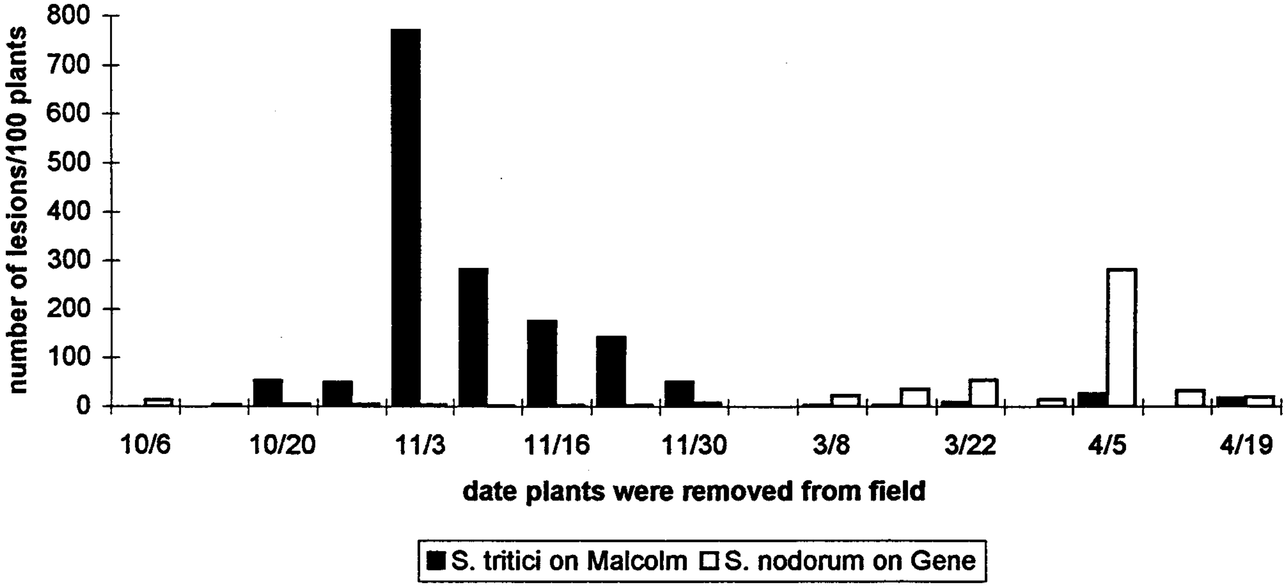

Fig. 2 Whole Plot Septoria (*S. tritici* and *S. nodorum*) Assessments, Milky Ripe, Corvallis, Unsprayed Plots

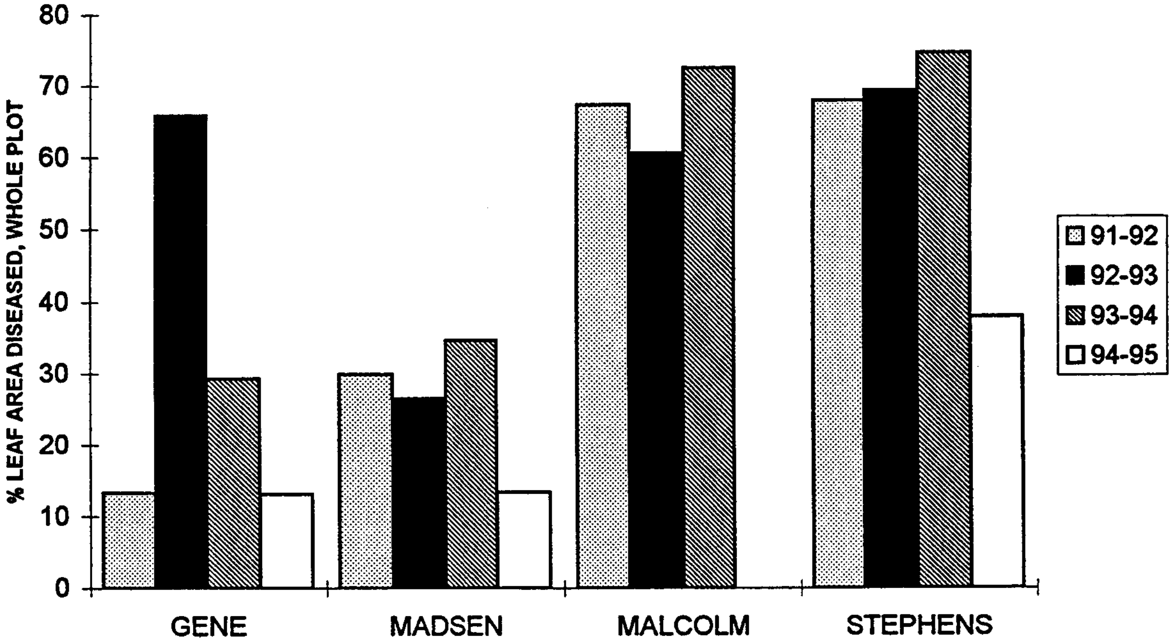

Fig. 3 Whole Plot Septoria Assessments, Milky Ripe, Aurora

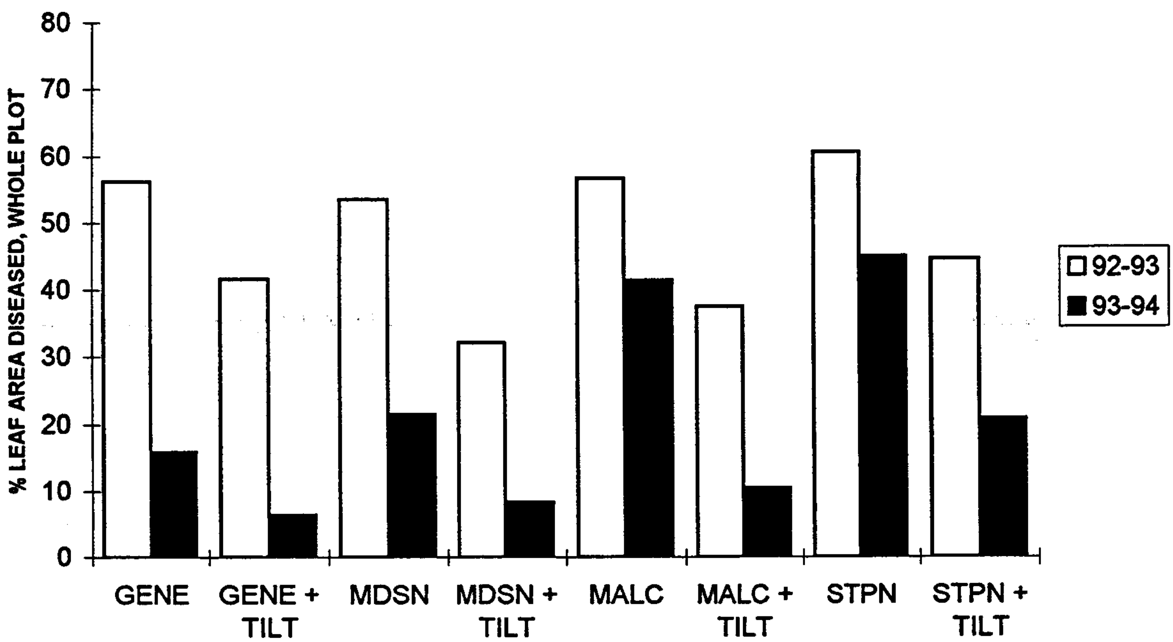

Table 1. Whole plot disease assessments for sprayed and unsprayed plots.[1]

1992 Treatment	% of Leaf Area Covered by Septoria Lesions			Avg. diff. between spryd. and unspryd [2]
	Corvallis	Kiger Island	Silverton	
Gene (- spray)	13.3	3.4	13.8	3.8%
Gene (+ spray)		2.8	6.9	
Madsen (- spray)	29.9	8.7	22.1	12.7%
Madsen (+ spray)		3.2	9.4	
Stephens (- spray)	67.8	39.1	49.6	19.7%
Stephens (+ spray)		25.2	24.2	

1993 Treatment	% of Leaf Area Covered by Septoria Lesions				Avg. diff. between spryd. and unspryd
	Aurora	Corvallis	Amity	Donald	
Gene (- spray)	56.2	65.8	59.1	40.6	17.6%
Gene (+ spray)	41.7		37.0	24.4	
Madsen (- spray)	53.5	26.5	66.1	35.6	22.3%
Madsen (+ spray)	32.2		35.6	20.5	
Stephens (- spray)	60.6	69.3	97.2	69.5	67.7%
Stephens (+ spray)	44.6		77.6	37.4	

1994 Treatment	% of Leaf Area Covered by Septoria Lesions		Avg. diff. between spryd. and unspryd
	Aurora	Corvallis	
Gene (- spray)	15.8	43.8	15.8%
Gene (+ spray)	6.4	21.6	
Madsen (- spray)	21.5	38.6	12.7%
Madsen (+ spray)	8.3	26.5	
Stephens (- spray)	45.0	76.0	32.6%
Stephens (+ spray)	20.8	35.0	

1995 Treatment	% of Leaf Area Covered by Septoria Lesions	Avg. diff. between spryd. and unspryd
	Corvallis	
Gene (- spray)	18.1	9.5%
Gene (+ spray)	8.6	
Madsen (- spray)	15.4	2.6%
Madsen (+ spray)	12.8	
Stephens (- spray)	26.1	12.4%
Stephens (+ spray)	13.7	

[1] Disease readings at Corvallis and Aurora were taken at milky ripe, and at all other sites at four weeks after flag leaf emergence. All fungicide applications were a single application of Tilt (4 fl oz/A) at Stephens flag leaf emergence.

[2] Average difference in the percentage of leaf area covered by septoria lesions between unsprayed and sprayed plots.

Table 2. Yield increases in sprayed plots. [1]

Year	Site	Yield (bu/a) increase due to fungicide Gene	Madsen	Stephens
1994	Corvallis	0	+15	+25
1994	Aurora	+12	-1	+20
1993	Corvallis	+14	+20	+24
1993	Aurora	+5	+16	+25
1993	Donald	+18	+22	+40
1993	Amity	+6	+12	+22
1992	Corvallis	+8	+3	+25
1992	Aurora	+1	+4	-12
1992	Silverton	+10	+6	+18
1992	Kiger Island	+3	+14	+18
1991	Corvallis	+20	+9	+9
1991	Aurora	+9	+1	-1
1990	Corvallis	+10	+10	+7
	Average	+9	+10	+17
Cost Effective Years [2]		8/13	8/13	11/13

[1] All fungicide applications were a single appliction of Tilt (4 fl oz/A) at Stephens flag leaf emergence.

[2] For this analysis, a fungicide treatment was considered cost effective if it resulted in a yield increase greater than 6 bu/A. This assumes a $15 spray + application cost; 3 bushel 'rundown' loss, and $4.50/bu wheat.

Table 3. Cultivar yields in sprayed and unsprayed plots.

Year	Site	Gene unsprayed	Gene sprayed [1]	Madsen unsprayed	Madsen sprayed	Stephens unsprayed	Stephens sprayed
1994	Corvallis	99	99	101	116	75	100
1994	Aurora	109	121	97	96	82	102
1993	Corvallis	92	106	68	88	70	94
1993	Aurora	99	104	87	103	65	95
1993	Donald	64	82	74	96	38	78
1993	Amity	83	89	86	98	43	65
1992	Corvallis	94	102	94	97	81	106
1992	Aurora	81	82	76	80	85	73
1992	Silverton	96	106	104	110	86	104
1992	Kiger Island	94	97	95	109	63	81
1991	Corvallis	98	118	108	117	92	101
1991	Aurora	97	106	116	117	110	109
1990	Corvallis	142	152	133	143	138	145

Averages	Gene unsprayed	Gene sprayed	Madsen unsprayed	Madsen sprayed	Stephens unsprayed	Stephens sprayed
	96	105	95	105	79	96

[1] All fungicide applications were a single application of Tilt (4 fl oz/A) at Stephens flag leaf emergence.

Table 4. Test weight values from sprayed and unsprayed plots.

Year	Site	Gene spryd.[1]	Gene unspryd.	Gene diff.[2]	Madsen spryd.	Madsen unspryd.	Madsen diff.	Stephens spryd.	Stephens unspryd.	Stephens diff.
1995	Corvallis	58.5	56.9	1.6	59.6	58.6	1.0	60.5	60.6	0.1
1994	Corvallis	59.5	58.6	0.9	62.5	62.1	0.4	60.5	57.3	3.2
1994	Aurora	61.6	61.1	0.5	62.7	62.9	-0.2	62.1	60.7	1.4
1993	Corvallis	55.5	52.6	2.9	59.8	56.9	2.9	57.0	54.5	2.5
1993	Aurora	55.3	54.3	1.0	55.9	54.9	1.0	55.3	52.1	3.2
1992	Corvallis	57.3	56.5	0.8	59.0	59.2	-0.2	58.9	57.8	1.1
1992	Aurora	58.0	58.2	-0.2	59.4	58.9	0.5	58.3	58.3	0.0
1991	Corvallis	58.6	57.4	1.2	60.7	60.0	0.7	60.8	59.8	1.0
1991	Aurora	56.8	56.9	-0.1	60.6	60.5	0.1	60.8	60.5	0.3
1990	Corvallis	60.0	59.0	1.0	62.3	62.4	-0.1	62.4	61.6	0.8
Averages		Gene spryd.	Gene unspryd.	Gene diff	Madsen spryd.	Madsen unspryd.	Madsen diff	Stephens spryd.	Stephens unspryd.	Stephens diff
		58.1	57.2	0.9	60.2	59.6	0.6	59.7	58.3	1.4

[1] All fungicide applications were single 4 oz. Tilt at Stephens flag leaf emergence.
[2] The differece in test weight between the sprayed and unsprayed treatments.

Table 5. 1994-1995 fungicide timing trial, Corvallis.

GENE Treatment	Percent leaf area infected	Height* (in)	Yield* (bu/a)	Change[1] in yield (bu/a)	Test* weight (lb/bu)
Unsprayed	22 c[2]	35	94	-	57.8
Early flag[3]	15 b	37	88	-6	58.1
Mid flag	14 b	34	91	-3	58.2
Late flag	14 b	37	100	+6	58.4
Flowering spray	23 c	36	92	-2	58.0
Early flag & flowering	14 b	37	95	+1	58.2
Mid flag & flowering	12 a	36	97	+3	58.2
Late flag & flowering	13 a	36	89	-5	57.9

MADSEN Treatment	Percent leaf area infected	Height (in)	Yield* (bu/a)	Change in yield (bu/a)	Test* weight (lb/bu)
Unsprayed	18 b	39 a	82	-	59.6
Early flag	13 ab	40 b	84	+2	59.5
Early flag and flowering	10 a	39 a	78	-4	59.8

STEPHENS Treatment	Percent leaf area infected	Height (in)	Yield* (bu/a)	Change in yield (bu/a)	Test* weight (lb/bu)
Unsprayed	29 d	39 b	80	-	60.5
Early flag	20 bc	37 a	75	-5	60.6
Early flag and flowering	19 abc	40 c	82	+2	60.8
Flowering	22 c	39 b	78	-2	60.5

* An asterisk indicates that there were no significant differences between treatments for this measurement.

[1] Increase or decrease in yield as compared to the unsprayed control. A yield increase of 6 bu/a is necessary in order to pay for the cost of the spray application (assuming a $15 spray + application cost, a 3 bushel 'rundown' loss, and a $4.50/bu wheat price).

[2] For each measurement, letters indicate statistically significant differences at the 5 percent level between treatments for each cultivar.

[3] Tilt at a rate of 4 oz/A was used for all flag leaf spray applications. Benlate/Mancozeb (4 oz/A Benlate 50 WP and 1.6 lb ai/A Mancozeb) was used for the applications applied at flowering.