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

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Biology and control of 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

Three septoria diseases occur in western Oregon. *Septoria tritici*, causal agent of septoria tritici blotch, is the most common. *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*.

Disease symptoms caused by *Septoria tritici* and *Septoria nodorum* are very similar. It is difficult to distinguish between the two diseases 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 between wheat crops on residues, volunteer wheat, and 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 late fall (November or December). Ascospore production of *Septoria nodorum* occurs in early 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 landing on a leaf, if conditions are favorable, a spore germinates and infects the leaf. The time between infection and development of a visible, sporulating lesion is called the latent period and is usually 14-21 days. During this period, the fungus must successfully infect and grow through the leaf. The lesions that form 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 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 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. On moderately resistant cultivars, such as Madsen, if the F-2 leaves have any lesions on them, our data indicate that there will be sufficient septoria to warrant a fungicide application. It is important to note that this type of monitoring is not a guaranteed predictor of the amount of septoria that will occur. For example, in the 1995-96 season, the F-2 leaves of Madsen did not have lesions at flag leaf emergence, but fungicide applications did result in yield gains.

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 is moderately resistant to the septoria diseases. The cultivar Gene has been considered resistant to *Septoria tritici*, but susceptible to *Septoria nodorum*. However, Gene has lost much of its resistance to *Septoria tritici*. In 1995-96, there was more *S. tritici* than *S. nodorum* on the flag leaves of unsprayed Gene plants. On the heads of unsprayed Gene plants, *S. nodorum* lesions were very common. Although this change has only been observed for one season, the management of disease on the cultivar Gene needs to be reconsidered.

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. One of the fungicides 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 (1.6 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 cannot be applied within 26 days of harvest. For the 1995-96 fungicide timing trial, the fungicide Quadris was included. The registration for Quadris is pending and anticipated in 1997. Quadris is a broad spectrum, protectant and systemic fungicide. The label for Quadris is expected to allow applications during flowering.[1]

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 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:

[1] 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. Information on the properties of Quadris was obtained from Zeneca, Inc.

(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 6.75 bu/A was necessary to pay for the cost of a fungicide application: ($15 spray cost ÷ $4.00/bu wheat price) + 3 bushels = 6.75 bushels.

Fungicide applications were effective in 13 out of 15 site/years for Stephens. In terms of yield increase, Stephens was the most responsive (average increase of 18 bushels), while Gene and Madsen were similar in their response (average of increase of 10 and 11 bushels, respectively) (Table 2). 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 (Tables 5 and 6). For most cultivars, one spray at early flag leaf emergence will increase yield sufficiently to pay for the spray. For the cultivar Gene, this single spray at flag leaf emergence is more effective when applied at late flag leaf emergence. 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 enough to pay for the cost of the spray. Some fungicides can be applied a second time at flowering. The data show that an application of Tilt during flag leaf emergence and an application of Benlate/Mancozeb during flowering will not give an economic yield return as compared to just applying the flag leaf application. The data for the fungicide timing trials are presented in Tables 5 and 6.

<u>1994-95 Fungicide Timing Trial</u>

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 (Table 5). 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 (Table 5).

The disease severity data from the 1994-95 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 is the reason that although there were statistically significant differences in disease, decreases in disease did not result in yield increases (Table 5).

1995-96 Fungicide Timing Trial

The 1995-96 season had high levels of disease, and therefore different levels of disease control resulted in statistically and economically significant yield differences (Table 6). For the 1995-96 trial, the second spray application was applied at heading instead of during flowering. Other differences between this trial and the 1994-95 trial include: 1. The early flag leaf application on Gene was planned but could not be applied due to weather conditions, 2. The fungicide Quadris was used on Gene with application timings at late flag and heading, 3. On Stephens, an application of Tilt+Benlate (pre-mixed) at early flag was included.

For Gene, the single application of Tilt at late flag was the most effective in controlling disease and resulted in a yield increase of 29 bu/A as compared to the unsprayed plots (Table 6). Although applying Tilt at late flag and Benlate/Mancozeb at heading resulted in less disease and a 31bu/A yield increase as compared to the unsprayed plots, the second fungicide application only increased yield by an additional 2 bu/A. This small yield increase is not enough to pay for the cost of the second application. The Quadris application at late flag was less effective at controlling disease than the Tilt application at late flag. The Quadris application at heading was much more effective than the Benlate/Mancozeb application at heading. It is interested to note that in 1995-96 *Septoria tritici* was causing most of the infections on the leaves on Gene in this experiment, and in 1994-95 *Septoria nodorum* was causing most of the infections on Gene. Despite this shift in the pathogen, and despite differences in the amount of disease, in both seasons the most effective treatment for Gene was a single application of Tilt at late flag.

For Madsen, the data from 1995-96 indicate that in a year with high disease severity, a single Tilt application at early flag results in an economic yield return. For Stephens, a single application of Tilt at early flag resulted in the best economic yield gain. Tilt alone performed as well as the pre-mixed Tilt+Benlate at early flag. Even in a season with such high levels of disease on Stephens, a second fungicide application did not increase yield enough to pay for the cost of the spray. A single application of Benlate/Mancozeb at heading on Stephens resulted in very little reduction in disease, and did not increase yield enough to pay for the cost of the spray.

Effect of head infections on the yield of Gene

Septoria nodorum infections on the heads of Gene are common, especially on unsprayed plants. *S. nodorum* does infect the seed, and these infections can result in shriveled, discolored seed. Although infected seed can cause seedling infections, data from previous experiments indicate that commercial seed treatments control *S. nodorum*. The control is so effective that seed-borne *S. nodorum* is not considered a significant source of inoculum. Infected seed is of lower quality, and head infections of *S. nodorum* are of concern for this reason. The data in Table 7 indicate that infected heads have fewer seeds per head and smaller seeds, and that this difference is statistically significant. Figure 4 shows the level of head infections on Gene in the 1995-96 fungicide timing trial. Fungicide applications applied during flag leaf emergence are effective at reducing the amount of *S. nodorum* infections on Gene heads. Additional fungicide applications during heading did not result in large decreases in disease on the heads of Gene. A single application of Benlate/Mancozeb during heading did not provide any disease control when compared to the unsprayed plots.

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 was considered resistant to *Septoria tritici*. For Gene, the data from the 1995-96 season suggest that this resistance is breaking down. For these two cultivars, it is especially important to monitor disease levels during the season, particularly at or just prior to flag leaf emergence, to determine the level of infection prior to spraying. If septoria lesions are present on the F-2 leaf, there will most likely be enough septoria to warrant a fungicide application. It is important to note that this type of monitoring is not a guaranteed predictor of the amount of septoria that will occur. 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. For Madsen and Stephens, the application should be made at early flag leaf emergence. For Gene, the application should be made at late flag leaf emergence. A late application or second application of a fungicide is very unlikely to result in enough of an increase in yield to pay for the cost of the application. If a second spray application is made, it should be applied within two to three weeks of the first application.

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 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.

Table 1. Whole plot disease assessments for sprayed and unsprayed plots, 1992-1994.[1]

1992 Treatment	% of Leaf Area Covered by Septoria Lesions: Corvallis	Kiger Island	Silverton	Avg. diff. between spryd. and unspryd[2]
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: Aurora	Corvallis	Amity	Donald	Avg. diff. between spryd. and unspryd
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: Aurora	Corvallis	Avg. diff. between spryd. and unspryd
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	

Table 1., continued

Whole plot disease assessments for sprayed and unsprayed plots, 1995 and 1996.[1]

1995 Treatment	% of Leaf Area Covered by Septoria Lesions: Corvallis	Avg. diff. between spryd. and unspryd
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	

1996	% of Leaf Area Covered by Septoria Lesions		Avg. diff. between
Treatment	Corvallis	Dayton	spryd. and unspryd
Gene (- spray)	79.9	52.8	44.9%
Gene (+ spray)	25.8	17.2	
Madsen (- spray)	29.5	47.5	23.0%
Madsen (+ spray)	12.8	18.3	
Stephens (- spray)	94.1	86.9	63.3%
Stephens (+ spray)	43.4	11.1	

[1] Disease readings at Corvallis, Aurora, and Dayton 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
1996	Corvallis	17	26	20
1996	Dayton	27	13	28
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	10	11	18
Cost Effective Years [2]		10/15	10/15	13/15

[1] All fungicide applications were a single application 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 6.75 bu/A. This assumes a $15 spray+application cost; 3 bushel 'rundown' loss, and $4.00/bu wheat.

Table 3. Cultivar yields in sprayed and unsprayed plots.

Year	Site	Gene sprayed	Gene unsprayed [1]	Madsen sprayed	Madsen unsprayed	Stephens sprayed	Stephens unsprayed
1996	Corvallis	105	88	129	103	120	100
1996	Dayton	126	99	123	110	123	95
1994	Corvallis	99	99	116	101	100	75
1994	Aurora	121	109	96	97	102	82
1993	Corvallis	106	92	88	68	94	70
1993	Aurora	104	99	103	87	95	65
1993	Donald	82	64	96	74	78	38
1993	Amity	89	83	98	86	65	43
1992	Corvallis	102	94	97	94	106	81
1992	Aurora	82	81	80	76	73	85
1992	Silverton	106	96	110	104	104	86
1992	Kiger Island	97	94	109	95	81	63
1991	Corvallis	118	98	117	108	101	92
1991	Aurora	106	97	117	116	109	110
1990	Corvallis	152	142	143	133	145	138
Averages		106	96	108	97	100	82

[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.
1996	Corvallis	57.6	55.6	2.0	60.9	58.4	2.5	60.6	59.1	1.5
1996	Dayton	58.8	55.4	3.4	60.8	60.0	0.8	61.4	58.9	2.5
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	56.9	1.2	60.3	59.5	0.8	59.9	58.4	1.5

[1] All fungicide applications were single 4 oz. Tilt at Stephens flag leaf emergence.
[2] The difference 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[2] in yield (bu/a)	Test weight (lb/bu)
Unsprayed	22 c[1]	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	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

[1] For each measurement, letters indicate statistically significant differences at the 5 percent level between treatments for each cultivar. If there are no significant differences, no letters are listed.

[2] Increase or decrease in yield as compared to the unsprayed control. A yield increase of 6.75 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 $4.00/bu wheat price).

[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.

Table 6. 1995-1996 fungicide timing trial, Corvallis.

GENE Treatment	Percent leaf area infected	Height (in)	Yield (bu/a)	Change[2] in yield (bu/a)	Test weight (lb/bu)
Unsprayed	82 e[1]	39	88 a	-	54.7 a
Tilt-mid flag	48 d	38	108 c	20	58.0 c
Tilt-late flag	23 a	39	117 d	29	59.6 e
Quadris-late flag[3]	45 cd	38	100 b	12	58.2 c
Benlate/Mancozeb-heading	80 e	39	95 b	7	56.2 b
Quadris-heading	41 c	38	110 c	22	58.0 c
Tilt-mid flag & heading[4]	32 b	38	113 c	25	58.4 c
Late flag & heading	18 a	38	119 d	31	59.0 d

MADSEN Treatment	Percent leaf area infected	Height (in)	Yield (bu/a)	Change in yield (bu/a)	Test weight (lb/bu)
Unsprayed	26 b	43 a	115 a	-	60.4
Tilt-early flag	12 a	46 b	125 c	10	60.8
Early flag & heading	12 a	46 b	124 b	9	60.7

STEPHENS Treatment	Percent leaf area infected	Height (in)	Yield (bu/a)	Change in yield (bu/a)	Test weight (lb/bu)
Unsprayed	91 b	43	91 a	-	58.4 a
Tilt-early flag	19 a	44	122 b	31	60.9 c
Tilt+Benlate-early flag[5]	19 a	43	128 b	37	61.3 c
Benlate/Mancozeb-heading	86 b	43	95 a	4	59.3 b
Early flag & heading	14 a	44	128 b	37	60.7 c

[1] For each measurement, letters indicate statistically significant differences at the 5 percent level between treatments for each cultivar. If there are no significant differences, no letters are listed.

[2] Increase or decrease in yield as compared to the unsprayed control. A yield increase of 6.75 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 $4.00/bu wheat price).

[3] A full registration for Quadris is pending and anticipated in 1997.

[4] For the treatments receiving more than one spray application, 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 heading.

[5] The Tilt label currently allows full rate Tilt application in combination with half rate of other products for control of foot rot and septoria. See the label.

Table 7. Seed number and weight from heads collected from plots of infected and uninfected Gene at Hyslop, 1995-96

Infected	seed number[1]	seed weight(g)[2]
Plot 1	1436	50.2
Plot 2	1597	63.2
Plot 3	1516	61.5
Plot 4	1756	74.9
Plot 5	1674	65.8
Plot 6	1651	62.7
Average	1605	63.1
Uninfected	seed number	seed weight(g)
Plot 1	1757	85.3
Plot 2	1741	78.0
Plot 3	1787	87.7
Plot 4	1647	78.8
Plot 5	1772	85.7
Plot 6	1652	78.8
Average	1726	82.4

[1] The average seed number for the infected and uninfected plots is statistically significant at $p \leq 0.04$.

[2] The average seed weight for the infected and uninfected plots is statistically significant at $p \leq 0.0004$.

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

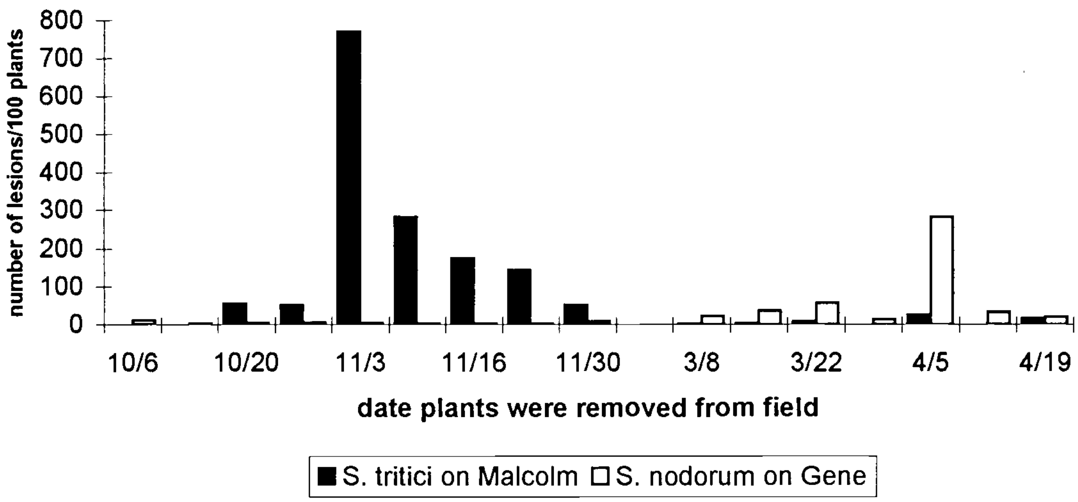

Fig. 2 Whole Plot Septoria (*S. tritici and S. nodorum*) Assessments, Milky Ripe, Corvallis, Unsprayed Plots

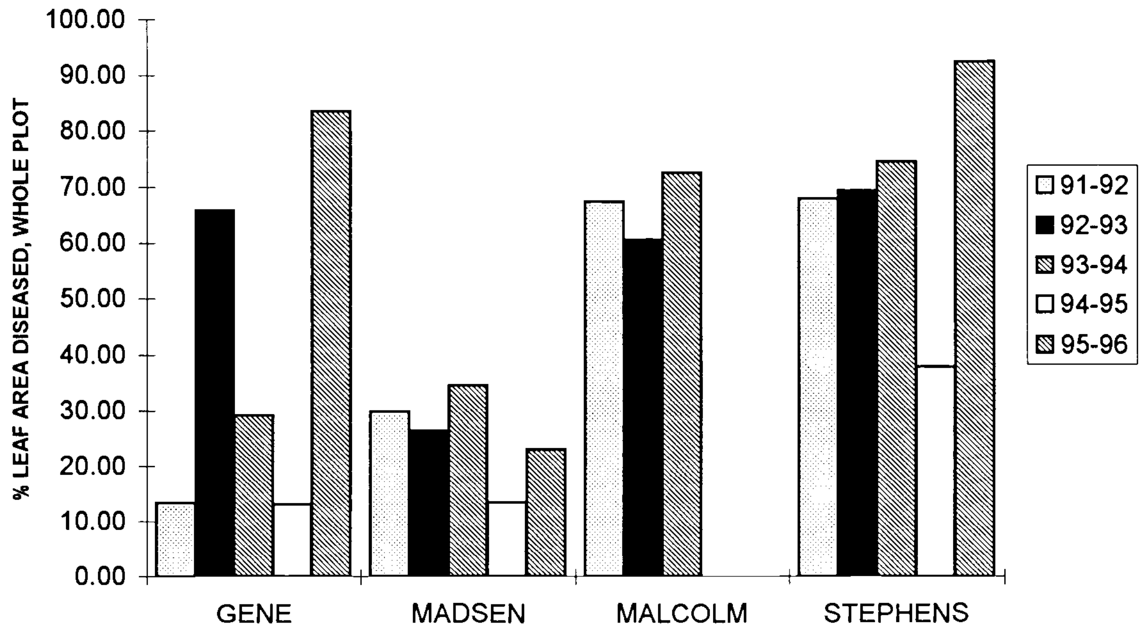

Fig. 3 Whole Plot Septoria Assessments, Milky Ripe, Aurora

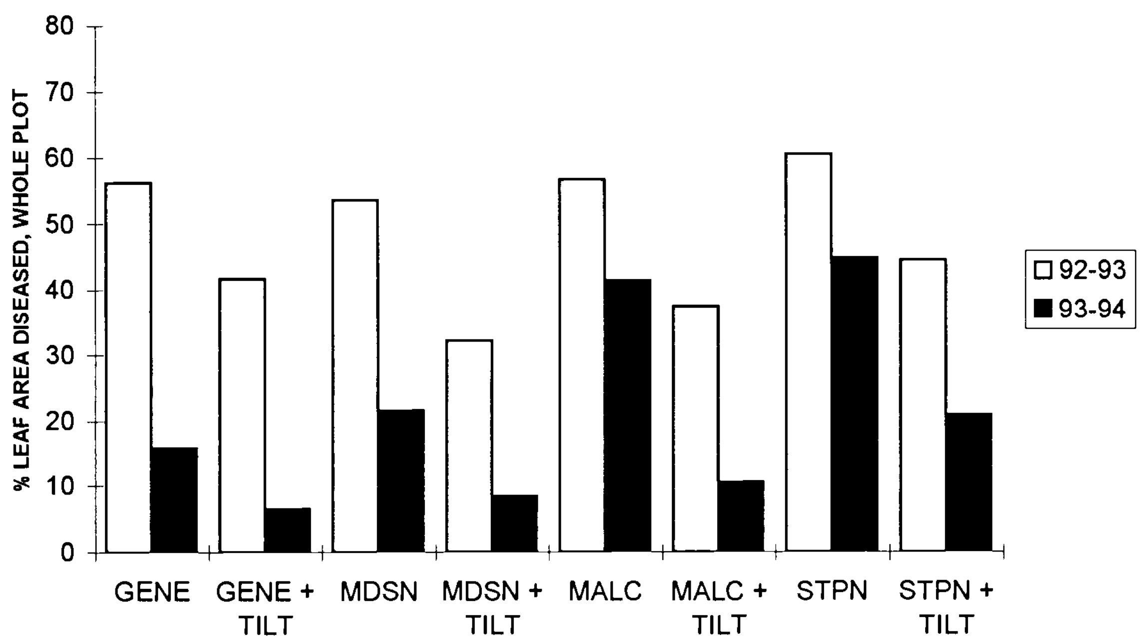

Fig. 4 Head infections on Gene, fungicide timing experiment, Corvallis, 1995-96