Expression and Effectiveness of Resistance in Wheat to Septoria Leaf Blotch

Gregory Shaner, Robert E. Finney, and Fred L. Patterson

Associate Professor and Research Associate, Department of Botany and Plant Pathology; and Professor, Department of Agronomy, Purdue University, West Lafayette, Indiana 47907.

Purdue University Agricultural Experiment Station Journal Series Paper No. 5690.

The authors thank Wayne Austin for technical assistance.

Accepted for publication 4 February 1975.

ABSTRACT

During 1973 and 1974 we evaluated wheat cultivars and breeding lines in severe epidemics of Septoria leaf blotch. We recognized two types of resistance. One, derived from the wheat cultivar Bulgaria 88, greatly reduced the number of pycnidia produced by the pathogen. The other, which apparently does not derive from any single cultivar, reduced the rate of disease development without greatly reducing the number of pycnidia. This resistance was expressed to a greater degree in later-maturing wheats. The expression of resistance derived from Bulgaria 88 was less affected by maturity. Leaf blotch severity was greater the earlier wheat was sown, on both resistant and susceptible lines. Resistance derived from Bulgaria 88 increased yields 10-20%. We are now attempting to combine the two types of resistance to achieve a higher level of disease control.

Phytopathology 65:761-766

Additional key words: Septoria tritici, Triticum aestivum, epidemiology, breeding for disease resistance.

Septoria leaf blotch of wheat (*Triticum aestivum* L. em Thell.), incited by *Septoria tritici* Rob. ex Desm. has received little attention from pathologists and breeders until recently (11). The disease may have increased in severity with the replacement of tall, late-maturing cultivars by short, early-maturing cultivars grown at high nitrogen levels. Early maturity, short stature, and high nitrogen levels apparently all favor leaf blotch (1, 2, 10, 11, 12). There is one contrary report (13) that taller wheats were more susceptible to leaf blotch than dwarf wheats.

In Indiana, in the spring, when winter wheat is in juvenile growth stages, leaf blotch is nearly always present except in fields that are planted late in the fall. In favorable weather, *S. tritici* spreads up the plant, killing progressively younger leaves until eventually it may kill the flag leaf.

Efforts to find resistance to Septoria leaf blotch began at Purdue University about 20 years ago. Narvaez (2) identified 140 resistant winter wheat cultivars. He considered wheats resistant if less than 30% of the surface of the upper five leaves was killed. He noted smaller lesion size and fewer pycnidia within lesions in these resistant wheats. By present-day standards, most of these cultivars were very late maturing under Indiana conditions, all heading after 23 May. Sewell and Caldwell (7) also noted a correlation between date of maturity and resistance. The cultivars of soft red winter wheat widely grown in this region (currently Arthur, Arthur 71, and Abe) usually head 17-21 May and are susceptible to leaf blotch.

Rosielle (6) rated 7,500 wheats in Australia for density of pycnidia in lesions and degree of coalescence of lesions (essentially, percentage severity), and found resistance among 34 cultivars of *T. aestivum* and 266 cultivars of *T. durum*. Some cultivars had extensive necrosis, but few pycnidia. Resistant cultivars tended to be late in maturing.

Little is known regarding the inheritance of resistance. In crosses with Knox or Vermillion, resistance in the winter wheat cultivar, Nabob, appeared to be conditioned by two independent genes, each lacking dominance but with additive effects (2). In the spring wheats Lerma 50 and P_{14} (a selection from the cross Yaqui 48/Kentana 48/Frontana), resistance was conditioned by a single dominant gene (2). Resistance in an Agrotricum line appeared to be carried on one Agropyron addition chromosome (5). In the winter wheat, Bulgaria 88, resistance in the mature plant is conditioned by a single dominant gene (4). This resistance has been particularly effective in Indiana, and it is the basis of resistance in Oasis (C.I. 15929) (3), a soft red winter wheat cultivar recently released in Indiana.

During 1973 and 1974, weather favored development of leaf blotch in Indiana, which afforded an opportunity to evaluate the resistance of Oasis in comparison with other cultivars and breeding lines. Except for one experiment, described below, the results reported here are based on leaf blotch epidemics in breeding nurseries.

MATERIALS AND METHODS.—We rated leaf blotch on breeding lines sown in four-row nursery plots 2.4 m long on three planting dates. The more promising breeding lines from previous years, and several check cultivars, were sown in field plots (30 × 1.6 m, with 17.5-cm row spacing) at two dates with four replications at each date, using a randomized complete block design within each date.

In 1973, severity was rated in nursery plots on a whole-plot basis, on a 0-5 scale, with 0 being essentially no disease, and 5 denoting plants nearly dead from disease. The density of pycnidia in lesions was scored on a scale of A-E. A, B, C, D, and E indicate no, sparse, moderate, dense, and very dense pycnidia, respectively. To further quantify this information, we examined leaf samples under a dissecting microscope fitted with a net reticule, to determine the number of pycnidia per mm^2 of lesion. The calculated densities were: A = 0; B = 2.00; C = 4.23; D = 8.45; and E = 12.02 pycnidia per mm^2. In 1974 we rated disease severity on a 0-9 scale. For each scale value we calculated the median percentage severity (Table 1) so that disease severity could be converted to percentages for analysis and presentation. Once the severity rating of 9 was reached (all lower leaves dead), we recorded only the percentage severity on the flag leaf. Pycnidial densities were again scored on the A-E scale.

In the field plots, percentage leaf blotch severity was

TABLE 1. Scale for rating Septoria leaf blotch severity on the upper four leaves of wheat[a]

Scale value	Leaf 1[b] (%)	Leaf 2 (%)	Leaf 3 (%)	Leaf 4 (%)	Mean severity (%)
1	0	0	0	0-5	1
2	0	0	0	5-20	3
3	0	0-tr	0-tr	20-50	9
4	0	0-tr	1-10	40-70	16
5	0	0-1	10-25	70-100	26
6	0	1-10	25-75	90-100	37
7	0	10-50	75-100	100	55
8	1-20	50-90	100	100	70
9	20-100	90-100	100	100	89

[a]Adapted from the rating scale of E. E. Saari and J. M. Prescott of the Rockefeller Foundation.
[b]Leaf 1 is the flag leaf.

estimated on the flag leaf and three leaves below it on each of 20 culms in each plot in 1973. Only one replication was examined. In 1974, we used the 0-9 scale to rate disease on each of 10 culms per plot in two or four replicates. In both years, severity was rated several times during the growing season.

In 1974, we conducted a date-of-planting experiment. Four cultivars and one breeding line that differed in maturity and leaf blotch resistance were sown on each of three dates. Each plot was a hill in which 15 seed were sown. Plots were laid out in a split plot randomized complete block design, with planting date as the main plot and genotype as the sub-plot, with six replications. On 20 June 1974, we rated severity on each of the upper three leaves on five culms per hill. The mean severity per culm in each plot was the datum analyzed.

RESULTS.—*Field plots.*—Leaf blotch epidemics were severe in both years (Table 2 and Fig. 1). Monon was nearly defoliated by the disease at the soft-dough stage of grain development. In 1973, the severities of leaf blotch on the various cultivars were not compared statistically

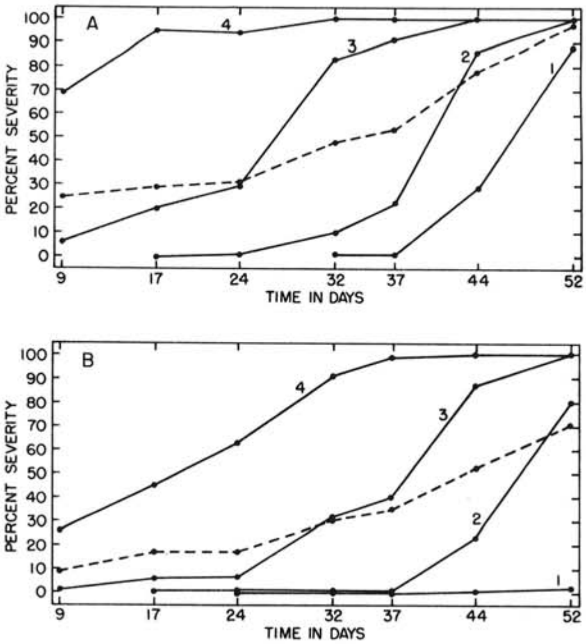

Fig. 1-(A, B). Disease progress curves for Septoria leaf blotch on each of the upper four leaves of **A)** 'Monon' and **B)** 'Blueboy' wheats in field plots at the Purdue University Agronomy Farm, 1973. Day 1 is 1 May. Leaf 1 is the flag leaf. The broken line is the average severity on the upper four leaves. Severity was estimated as the percentage leaf area killed by *Septoria tritici*.

since only one plot of each cultivar was examined. Nevertheless, the large differences between cultivars suggested real differences in the amount of disease, and this was borne out by statistical analysis of the 1974 data. Based on severity, Monon can be described as extremely susceptible; the next four cultivars are susceptible, but beginning with Knox 62 a degree of resistance becomes

TABLE 2. Septoria leaf blotch development on wheat in field plots at the Purdue Agronomy Farm, Lafayette, Indiana

Cultivar	Days later than cultivar Benhur in heading	Leaf blotch severity[a] 1973[b] (%)	Leaf blotch severity[a] 1974[c] (%)	Apparent infection rate, per unit per day[d] 1973	Apparent infection rate, per unit per day[d] 1974
Monon	1	97.0	90.4 A	.118 A	.116 A
Abe	2	87.5	86.0 AB	.085 C	
Arthur	2	91.2	84.6 AB	.087 BC	.092 B
Benhur	0	95.8	83.2 AB	.112 AB	
Arthur 71	2	89.8	80.0 BC	.088 BC	
Knox 62	1		74.2 CD		.114 A
Stoddard	5		70.8 DE		
Blueboy II	3	70.2	67.1 DEF	.079 C	
Logan	8		64.6 EFG		
Vigo	11		60.0 FGH		
Redcoat	9	66.2	57.7 GH		
Oasis	2	81.0	55.2 H		

[a]Percentage of area of upper four leaves showing symptoms. Means followed by a common letter do not differ significantly, $P=0.05$ by Duncan's multiple range test.
[b]Data taken on 20 culms in one plot of each cultivar 21 June 1973.
[c]Data taken on 10 culms in each of two plots of each cultivar 17 June 1974.
[d]See Page 20 *in* Literature Cited reference (14). Rates followed by a common letter do not differ significantly, $P=0.05$ by Duncan's multiple range test. Each year was analyzed separately.

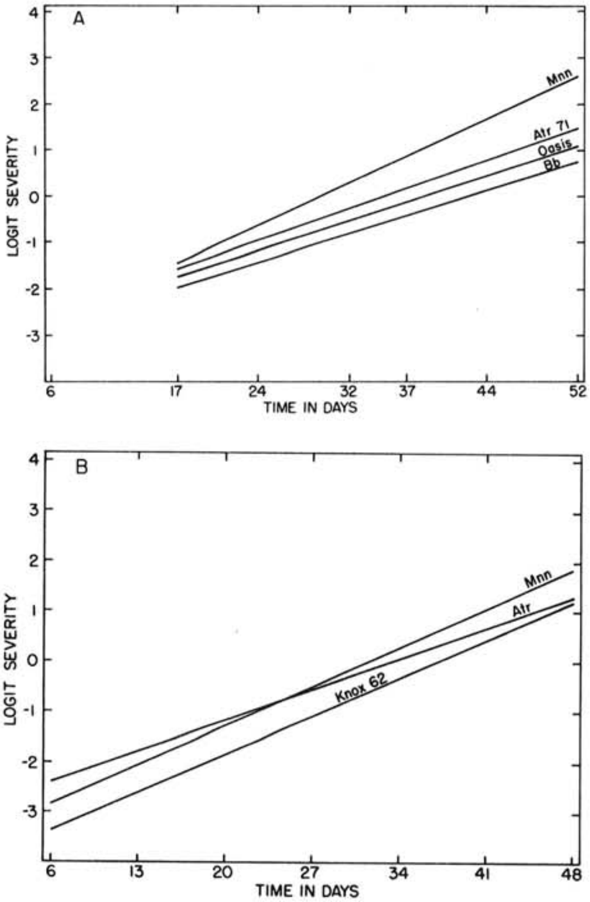

Fig. 2-(A, B). Disease progress curves for Septoria leaf blotch on 'Monon' (Mnn), 'Arthur 71' (Atr 71), 'Oasis', 'Blueboy' (Bb), 'Arthur' (Atr), and 'Knox 62' wheats in field plots at the Purdue University Agronomy Farm in **A**) 1973 and **B**) 1974. Day 1 is 1 May. Logit severity = $\log_e[X/(1-X)]$ where X is the proportion of diseased tissue. See Table 2 for apparent infection rates.

apparent. There is a clear relationship between the severity of disease and the lateness of maturity, except for Oasis. Oasis is as early as the other Arthur-type wheats (Arthur, Arthur 71, Abe), which it resembles closely.

The differences in severity among cultivars were even more striking in the field than Table 2 shows. The upper two leaves of cultivars at 80% or more severity were heavily infected, whereas these leaves on cultivars at 60% severity were only moderately infected, the flag leaf often being nearly free of infection (see Table 1). Because of the flag leaf's considerable contribution to yield, this difference in infection could greatly influence yield reduction from the disease.

For cultivars in Table 2 that were inspected at approximately weekly intervals during the growing season, disease increased logarithmically, so we used logit analysis to determine apparent infection rates (14). The correlation coefficients of logit severity on time were high ($0.91 < r < 0.99$); therefore linear regression analysis was used to determine the apparent infection rate, which is the slope of the regression line. Some of the lines, illustrated in Fig. 2, differ both in slope and position. Within each year, significant differences were found among apparent infection rates (Table 2). Thus, two related criteria–apparent infection rate, and disease severity at the soft dough stage of development–showed significant differences in susceptibility. Monon is an extremely susceptible cultivar; Oasis and Blueboy are among the more resistant.

It is evident from Table 2 that the later-maturing cultivars had less leaf blotch than the earlier ones. The curves of Fig. 1 and 2, and the apparent infection rates in Table 2, are based on calendar time. But, for any given time the various cultivars were at different developmental stages. We plotted severity against developmental time (days after heading) to put the disease progress curves on the same developmental time scale. The pattern illustrated by the flag-leaf data is typical of that for all four upper leaves (Fig. 3). Despite the adjustment to a common developmental time scale, severity was less on the later-maturing Blueboy than on the earlier-maturing cultivars.

On 12 June 1974, we recorded pycnidial densities. Frequency distributions of plants among each pycnidial density class reveal differences among cultivars in this expression of resistance (Table 3). Using the density of pycnidia for each scale value, we calculated a mean density of pycnidia per mm^2 of lesion for each cultivar (Table 3). For the early-sown wheat there was a substantial difference in pycnidial density between Oasis and the other cultivars. Arthur 71 had significantly fewer pycnidia than Arthur and Abe. The differences in percentage severity followed generally the same pattern as differences in pycnidial density.

For plantings made at the late sowing date, disease severity and pycnidial density were about half of that observed in those made at the early sowing date. Pycnidial density on Oasis was essentially unaffected by

Fig. 3. Disease progress curves for Septoria leaf blotch on 'Monon' (Mnn), 'Arthur' (Atr), 'Benhur' (Bhr), 'Oasis' and 'Blueboy' (Bb), on a time scale adjusted for differences in date of heading. Data are from plots at the Purdue University Agronomy Farm, 1973.

TABLE 3. Production of pycnidia of *Septoria tritici* and disease severity on the Arthur-type wheats sown at two dates, Lafayette, Indiana

Date sown	Cultivar	Percentage of plants in each pycnidia density category[a] A	B	C	D	E	Pycnidia (no. per mm^2 of lesion[b])	Disease severity (%)[b] 12 June	17 June
9-28-73	Arthur			.025	.300	.675	10.75 A	77.7 A	84.6 A
	Abe			.025	.225	.750	11.02 A	78.6 A	86.0 A
	Arthur 71			.200	.600	.200	8.32 B	60.3 B	80.0 A
	Oasis	.925	.050	.025			0.20 C	43.2 C	55.2 B
10-25-73	Abe		.175	.550	.250	.025	5.09 A	32.0 A	43.1 A
	Arthur 71		.200	.650	.150		4.42 A	31.3 A	50.8 B
	Oasis	.825	.150	.025			0.40 B	33.0 A	39.6 A

[a]Based on examination of 10 culms in each of four replications on 12 June 1974.

[b]Data were analyzed for each planting date and observation time separately. Means followed by the same letter do not differ significantly, $P = 0.05$ by Duncan's multiple range test. The severities on 17 June on the early sown wheat are the same as reported in Table 2, but are repeated here for ease of comparison.

TABLE 4. Relation between heading date and Septoria leaf blotch severity (%) on flag leaves of wheat on 20 June 1974.

Yield nursery or cross	Correlation coefficient (r)	Mean heading date (May)	Mean leaf blotch severity
Advanced Yield	−0.49452	19.7	28.0%
Preliminary A	−0.61386	21.4	47.1%
Preliminary B	−0.42470	21.1	30.6%
Specific crosses[a]			
66289	−0.47690	20.3	33.0%
6413	−0.77484	24.0	2.5%
67129	−0.35431	17.9	35.4%
65256	−0.57337	22.4	19.2%

[a]Within each cross there were 22 to 50 lines.

sowing date, being quite low at both dates. Severity was less on the late-sown Oasis, but not as much as on the other three cultivars.

Nursery plots.—Nursery plots provided data on the effects of maturity and the resistance from Bulgaria 88 on leaf blotch development on a diverse group of wheats. Several hundred breeding lines were examined. The lines that evidently carried resistance from Bulgaria 88 (based on their pedigree and the general absence of pycnidia on their leaves) had an average severity of 12% on the flag leaf on 20 June 1974, compared to an average of 28% on the flag leaf for all entries without the specific gene for resistance. Of the 43 lines which appeared to have Bulgaria 88 resistance, 24 had a severity of 5% or less.

The association between late maturity and low leaf blotch severity was evident in the breeding lines that did not carry resistance from Bulgaria 88 (Table 4). There was about a 15-day interval in heading between the earliest and latest wheats. Within the progeny of individual crosses this relationship was also evident. Four examples appear in Table 4. Despite the tendency of early wheats to be more susceptible to leaf blotch, there were lines without resistance from Bulgaria 88, near Arthur in maturity, but which had much less leaf blotch than Arthur. Severity on flag leaves was less than 10% on 26 of these lines that headed from 17-21 May compared to 48% on Arthur, which headed 19 May. Eleven of these lines were as early as, or earlier than, Arthur in heading. This resistance was associated with a lower density of pycnidia, but not as much as the resistance from Bulgaria 88. Of 61 lines that had a severity of 10% or less on the flag leaf, pycnidial densities ranged from A to E. The frequency distribution was as follows: A-4, B-15, C-21, D-18, E-3.

TABLE 5. Yield and Septoria leaf blotch severity on the four Arthur-type wheats in the Advanced Yield Nurseries, 1973 and 1974, Lafayette, Indiana

Cultivar	Yield[a] (metric tons/hectare) 1973 3 Oct[c]	1973 20 Oct	1974 28 Sept	1974 10 Oct	1974 19 Oct	Septoria leaf blotch severity (%) 1974 28 Sept	10 Oct	19 Oct
Oasis	4.09 A	4.60 A	3.29 A	3.92 A	4.09 A	43 A	41 A	38 A
Arthur 71	3.39 B	3.82 A	2.93 B	3.58 A	3.66 B	86 B	55 B	54 B
Abe	3.40 B	4.51 A	2.83 B	3.80 A	4.05 A	89 B	56 B	55 B
Arthur	3.97 A	4.52 A	2.96 B	3.92 A	3.56 B	88 B	65 B	69 B
Yield increase from Oasis' resistance[b] (%)	20.7	20.5	12.4	9.4	11.8			

[a]Statistical comparisons were made among cultivars within each year and planting date separately. Means followed by a common letter do not differ significantly, $P = 0.05$, by Duncan's multiple range test.

[b]Yield increase (%) of cultivar Oasis relative to cultivar Arthur was calculated: $\frac{\text{Oasis yield} - \text{Arthur 71 yield}}{\text{Arthur 71 yield}} \times 100$.

[c]Planting date.

TABLE 6. Effect of sowing date and resistance on severity[a] (%) of Septoria leaf blotch of wheat in hill plots

Planting date	Cultivar or line					Planting date means
	Monon	Arthur 71	Oasis	Purdue 6413	Redcoat	
9/24/73	83.2	70.9	73.3	55.3	51.0	66.7
10/05/73	78.3	60.3	40.5	54.0	36.3	53.9
10/18/73	76.3	66.6	30.9	44.1	34.5	50.4
Cultivar means	79.2	66.0	54.8	51.1	40.5	57.0
Days later than Monon	0	1	1	4	8	

Standard errors ($P = 0.05$)

Difference between	SE
Two planting dates	1.63
Two cultivar means	4.02
Two cultivar means in the same planting date	6.97
Two planting date means:	
i) for the same cultivar or,	6.44
ii) two planting date means for different cultivars	6.44

[a]Severity notes taken 20 June 1974.

The resistance to leaf blotch that is expressed as a lower severity of disease may be more subject to environmental modification than that conferred by the gene from Bulgaria 88. To obtain some indication of the reliability of selection for this resistance, we compared the behavior of lines selected in 1973 for a low level of leaf blotch with their leaf blotch severity in 1974. Fifty-two lines that had a rating of 2 or less in 1973 (on a 0-5 scale), and that could not carry resistance from Bulgaria 88, were grown in 1974. Their average heading date in 1974 was 4.5 days later than Arthur, and the average severity of leaf blotch on their flag leaves was 8%, compared to 48% for Arthur. We recognized some of these lines in the epidemic of 1970 as having "green leaves" when the leaves of most lines were dead from leaf blotch. Thus, this trait has held up during three epidemic years, suggesting that it is reasonably stable under our conditions.

The four Arthur-type wheats were replicated five times within each planting date in the yield nursery. In 1974, we estimated leaf blotch severity in each of these plots on 12 June, using the 0-9 scale. The center two rows of each plot were harvested for yield data. Except for Oasis, leaf blotch was considerably more severe in the wheat sown 28 September than on that sown later (Table 5). There was little difference in severity on each cultivar between the 10 October and 19 October sowings. Regardless of sowing date, Oasis had the least disease and consistently had the highest yield of the four cultivars. We calculated the yield increase due to leaf blotch resistance by comparing Oasis with Arthur 71. In the absence of leaf blotch these cultivars will yield about the same (3). The percentage increase in yield of Oasis over Arthur 71, therefore, indicates the value of the resistance from Bulgaria 88. Averaged over planting dates and years, Oasis yielded 15% more than Arthur 71 in epidemics of leaf blotch.

Date-of-planting experiment.—This experiment confirmed our observations in the larger plots of the breeding nurseries, and permitted statistical comparison of planting dates. Leaf blotch was most severe in the earliest planting (Table 6). Monon was the most susceptible cultivar, followed by Arthur 71. The 11-day delay of the second planting date reduced disease severity more than the 13-day additional delay of the third planting date. Cultivars did not respond alike to planting date, indicated by significant interactions. Only Oasis and Purdue 6413 showed a significant reduction in disease severity over the second interval in sowing date. The severity estimates of leaf blotch in the early planting may have been biased upward by necrosis from barley yellow dwarf virus infection in this treatment. In this experiment, as in the yield nurseries, the later-maturing wheats had less leaf blotch.

DISCUSSION.—The epidemics of leaf blotch in the past two years have clearly demonstrated the destructive potential of this disease. All leaves of a completely susceptible cultivar (such as Monon) can be killed prematurely by this fungus. The apparent infection rates on susceptible wheats are lower than those reported for some of the rusts of wheat, and are similar to those for powdery mildew (8, 9, 14). However, *Septoria tritici* begins its spread in early spring, so that at the measured rates leaf blotch can reach virtually 100% severity by the mid-dough stage.

In past years, it was recommended that growers in central Indiana sow wheat no earlier than 28 September to avoid Hessian fly infestations. With the introduction of fly-resistant wheats, many farmers now sow earlier than this. Our data of the past two years indicate that such early sowing increases the chance of severe damage by leaf blotch. By sowing after 10 October there is less chance of severe leaf blotch. We have also observed yellow dwarf, wheat spindle streak and take-all (incited by *Ophiobolus graminis*) to be less severe on later-sown wheat. Leaf rust and powdery mildew may be more severe on such wheat; however, the Arthur-type wheats are resistant to those diseases. There is some risk in sowing after 10 October because of weather. In most years wheat sown before the third week of October survives the winter well, but in occasional years winter-kill may be significant. This risk may be more than offset by the disease control effected.

Cultivar Oasis, which was bred for leaf blotch resistance, performed well in the epidemics. It was the least affected wheat in its maturity class and compared favorably with later-maturing cultivars. Oasis has a resistance like that mentioned by Rosielle (6). Fruiting of the pathogen is greatly reduced, but there can be considerable necrosis under the heavy inoculum load of a breeding nursery. Thus, our data probably underestimate the effectiveness of Oasis' resistance. In a large field, severity of leaf blotch would probably be less than we observed. Another cause of necrosis on leaves of Oasis is *Septoria nodorum* infection. Late in the season light infections appeared on leaves. Fortunately, the Arthur-type wheats have some resistance to glume blotch. In 1974, glume blotch reached 100% severity on heads of a few cultivars, but severities were less than 5% on the Arthur-type wheats. Even in our nurseries Oasis had effective leaf blotch resistance, which provided a 10-20% yield increase. Because disease control was not complete, the loss from leaf blotch these past two years with susceptible cultivars must have been in excess of 20%. With widespread epidemics of leaf blotch in Indiana and adjacent states, the financial benefit from growing a resistant cultivar would be considerable.

In an epidemic, recognition of breeding lines with the Bulgaria 88 resistance is not too difficult; disease severity is low and pycnidia are rare. When leaf blotch is not severe, resistant lines can be recognized by the absence of pycnidia on lower leaves. Another kind of resistance we recognize by a lower severity, but it may not be associated with fewer pycnidia in lesions. In a severe epidemic, the upper two leaves of lines with this resistance are green when all leaves of susceptible lines are dead. We call this resistance "green-leaf resistance" to distinguish it from the type of resistance observed in Oasis. There was a correlation between date of maturity and green-leaf resistance, but some resistant lines were not much later than Arthur. In the absence of leaf blotch, these lines display a delayed senescence of leaves. Recognition of green-leaf resistance depends on adequate disease development. In years when *S. tritici* fails to spread upward from lower leaves, the difference between resistant and susceptible lines is too slight for reliable selection.

The correlation between late maturity and leaf blotch severity is clear; the reasons for it are not. There are several possible explanations. Septoria leaf blotch is a disease of cool, wet weather (2, 11). Such weather is more likely to occur early in the growing season. The period of greatest disease development seems to be from flowering through dough development (Fig. 1.), so that a cultivar that passes through these stages earlier is more likely to encounter cool weather. Thus, green-leaf resistance might be an escape mechanism, and in a genetic sense may be conditioned not by genes for "resistance", but by genes for delayed maturity. Something other than escape must be involved in the early-maturing "green-leaf" wheats. There may be physiologic conditions associated with delayed senescence that condition resistance, more-or-less independently of weather, or possibly genes for resistance are associated with late maturity through linkage, or are more strongly expressed in a late-maturing wheat.

In breeding Oasis, we put the resistance from Bulgaria 88 into an Arthur 71 background because this represented the highest yield potential, quality, and resistance to other diseases for our region. In Oasis, the gene from Bulgaria 88 must operate in a fairly susceptible background. Although Oasis has out-yielded Arthur 71 by 10-20%, it may not embody the full potential of this gene to protect against leaf blotch. We now wish to combine green-leaf resistance with the specific Bulgaria 88 resistance. Desired combinations would be recognized from a lower severity of leaf blotch than on Oasis, but with little or no fruiting of the pathogen. If it does not prove possible to put adequate green-leaf resistance into a wheat of Arthur maturity then we might develop a slightly later-maturing cultivar, scarificing two or three days earlier maturity for the added protection against leaf blotch.

LITERATURE CITED

1. BRÖNNIMAN, A., A. FOSSATI, and F. HANI. 1973. Ausbreitung von Septoria nodorum Berk. und Schädigung bei kunstlich induzierten Halmlänge–Mutanten der Winterweizensorte 'Zenith' (Triticum aestivum). Z. Pflanzenzucht. 70:230-245.
2. NARVAEZ, I. 1957. Studies of Septoria leaf blotch of wheat. Ph.D. Thesis, Purdue University, West Lafayette, Indiana. 101 p.
3. PATTERSON, F. L., J. J. ROBERTS, R. E. FINNEY, G. E. SHANER, R. L. GALLUN, and H. W. OHM. 1974. Oasis soft red winter wheat, resistant to Septoria leaf blotch. Indiana Agric. Exp. Stn. Bull. 40. 5 p.
4. RILLO, A. O., and R. M. CALDWELL. 1966. Inheritance of resistance to Septoria tritici in Triticum aestivum subsp. vulgare, 'Bulgaria 88.' Phytopathology 56:897 (Abstr.).
5. RILLO, A. O., R. M. CALDWELL, and D. V. GLOVER. 1970. Cytogenetics of resistance to wheat leaf blotch (Septoria tritici) in backcross derivatives of an Agrotricum line. Crop Sci. 10:223-227.
6. ROSIELLE, A. A. 1972. Sources of resistance in wheat to speckled leaf blotch caused by Septoria tritici. Euphytica 21:152-161.
7. SEWELL, W. O., and R. M. CALDWELL. 1960. Use of benzimidazole and excised wheat seedling leaves in testing resistance to Septoria tritici. Phytopathology 50:654 (Abstr.).
8. SHANER, G. 1973. Evaluation of slow-mildewing resistance of Knox wheat in the field. Phytopathology 63:867-872.
9. SHANER, G., and R. L. POWELSON. 1971. Epidemiology of stripe rust of wheat, 1961-1968. Oreg. Agric. Exp. Stn. Tech. Bull. 117. 31 p.
10. SHIPTON, W. A. 1966. Septoria leaf spot and glume blotch of wheat. J. Agric., West. Aust. 7:160-163.
11. SHIPTON, W. A., W. R. J. BOYD, A. A. ROSIELLE, and B. I. SHEARER. 1971. The common Septoria diseases of wheat. Bot. Rev. 37:231-262.
12. STEWART, D. M., A. HAFIZ, and I. ABDEL HAK. 1972. Disease epiphytotic threats to high yielding and local wheats in the Near East. FAO (Food Agric. Organ., UN) Plant Prot. Bull. 20:50-57.
13. TYAGI, P. D., L. M. JOSHI, and B. L. RENFRO. 1969. Reaction of wheat varieties to Septoria tritici and report of an epidemic in northwestern Punjab. Indian Phytopathol. 22:175-178.
14. VAN DER PLANK, J. E. 1963. Plant diseases: Epidemics and control. Academic Press, New York. 349 p.