Interactions Between Septoria nodorum Leaf Blotch and Leaf Rust on Soft Red Winter Wheat

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Contribution 1589, Department of Plant Pathology, Pennsylvania Agricultural Experiment Station. Authorized for publication as Journal Series Paper 7519.

Special thanks to J. A. Frank, USDA-ARS, Pennsylvania State University, who served as thesis coadvisor during this research.

The terminology used in this paper is consistent with thát proposed at the International Workshop on *Septoria* Diseases held at Montana State University, Bozeman, August 1983.

Accepted for publication 10 March 1987.

ABSTRACT

Spadafora, V. J., and Cole, H., Jr. 1987. Interactions between Septoria nodorum leaf blotch and leaf rust on soft red winter wheat. Phytopathology 77:1308-1310.

Interactions between Septoria nodorum leaf blotch and leaf rust were investigated under field conditions in Pennsylvania in 1985 and 1986. Various levels of leaf rust severity were established by altering the frequency and timing of triadimefon fungicide applications. Analyses of variance indicated significant effects of fungicide treatments on the severity of leaf rust but no effects on the severity of Septoria nodorum leaf blotch in both years. Regression analyses on treatment means, however, indicated significant inverse relationships between the severities of the two diseases. Control of leaf rust with specific fungicides may increase the potential for Septoria nodorum leaf blotch epidemics and should be considered in the evaluation of narrow-spectrum fungicides.

Septoria nodorum leaf blotch is an important disease of soft red winter wheat in the eastern United States, causing an estimated 2–5% annual yield loss in Pennsylvania (1). The disease is induced by two fungal species, *Leptosphaeria nodorum* Müller (anamorph: *Septoria nodorum* Berk.) and *Mycosphaerella graminicola* (Fuckel) Schroeter (anamorph: *Septoria tritici* Rob. ex Desm.). The two diseases are referred to as Septoria nodorum leaf blotch and Septoria tritici blotch, respectively. Of the two diseases, Septoria nodorum leaf blotch is more prevalent in Pennsylvania. Other important foliar diseases of wheat in Pennsylvania include powdery mildew (*Erysiphe graminis* DC. f. sp. *tritici* E. Marchal) and leaf rust (*Puccinia recondita* Rob. ex Desm. f. sp. *tritici*) (D. Binghaman, *unpublished*).

There are conflicting reports concerning interactions between *L. nodorum* and other foliar pathogens of wheat and between *M. graminicola* and other pathogens (18). Infections by *P. recondita* and *E. graminis* have been reported to predispose plants to infection by *L. nodorum* (3,22). Hyde (9,10), however, reported no synergistic interactions between *L. nodorum* and *P. recondita* or between *L. nodorum* and *P. striiformis*, the causal agent of stripe rust. Chester (6) reported that infection by *M. graminicola* was associated with a reduced severity of leaf rust. Madariaga and Scharen (14,15) demonstrated that infection by *M. graminicola* reduced subsequent colonization of leaf tissue by *P. striiformis*.

Powdery mildew and leaf rust may be controlled by foliar application of triadimefon fungicide in intensive wheat production systems (7,12). Triadimefon, however, has little activity against *L. nodorum* under field conditions (19). Specific control of powdery mildew and leaf rust may reduce competition with *L. nodorum* and increase the potential for epidemics of Septoria nodorum leaf blotch (5,8). This study was conducted to investigate interactions between Septoria nodorum leaf blotch, powdery mildew, and leaf rust under field conditions.

MATERIALS AND METHODS

Experiments were conducted during the 1985 and 1986 growing seasons at the Pennsylvania State University Rock Springs Agricultural Research Center in Centre County. Field plots of the soft red winter wheat cultivar Hart were established using cultural practices recommended for central Pennsylvania (2). This cultivar is susceptible to Septoria nodorum leaf blotch, leaf rust, and powdery mildew. Plots were 4.9 × 7.5 m in 1985 and 2.4 × 7.6 m in 1986 and were surrounded on all sides by at least 1.5 m of barley (*Hordeum vulgare* 'Pennrad') that was periodically cut to ground level. Plots were seeded at a rate of 168 kg/ha to a depth of about 3.8 cm with a commercial grain drill at a row spacing of 17.5 cm. Planting dates were 18 September 1984 and 19 September 1985. Fertilization consisted of 90.7 kg/ha of 10-10-10 (NPK) applied at planting and 67 kg/ha of N applied as ammonium nitrate in April of each year. The herbicide MCPA (Weedar) (0.58 L a.i./ha) was applied at the Feekes growth stage (GS) 4–5 (13).

Triadimefon (Bayleton 50WP) was used to establish various levels of powdery mildew and leaf rust severity. Fungicide treatments were applied at a rate of 35 g a.i./ha with a tractor-mounted boom sprayer that delivered 45 L/ha (30 gal/acre) of material at 241.3 kPa (35 psi). Similar rates of triadimefon have not affected epidemics of *L. nodorum* in previous studies (19). The frequency and timing of fungicide applications were varied, incorporating applications at GS 5, 7, 9, 7+9, and 7+9+10. Unsprayed plots served as controls. Treatments were arranged in a randomized complete block design with four replicates.

The severities of powdery mildew, leaf rust, and Septoria nodorum leaf blotch were assessed on 10 randomly selected tillers per plot at GS 11.2. The severity of each disease was estimated visually on the upper three fully expanded leaves with standard area diagrams (4,11). Plots were harvested with a combine modified for field plot experimentation, and yields were adjusted to 13% moisture. Thousand-kernel weights (TKW) were estimated from a sample of 500 kernels per plot.

Data were analyzed by a two-way analysis of variance. Fungicide treatment means were separated by the Waller-Duncan method (17). Relationships between leaf rust and Septoria nodorum leaf blotch severities were determined for each year by regression analysis (16). Data for Septoria nodorum blotch were analyzed by a two-way analysis of variance, and treatment sums of squares were partitioned into sums of squares for regression and sums of squares for deviation. Septoria nodorum leaf blotch severity was treated as the response variable and leaf rust severity as the predicator variable (Table 1). Data for powdery mildew were not analyzed, because disease severities were lower than 5% in all plots.

Relationships between yield and the severities of Septoria nodorum leaf blotch and leaf rust were investigated by multiple-regression analysis using data from individual plots. The significance of regression parameters was tested using *t* ratios (16).

RESULTS

Environmental conditions were unfavorable to the development of powdery mildew in both years. Average severities were less than 5%, and significant effects of fungicide treatments were not detected ($P \leqslant 0.05$).

Leaf rust and Septoria nodorum leaf blotch were observed in both years and developed rapidly after GS 10.5. Severities of Septoria nodorum leaf blotch ranged from 34 to 57% at GS 11.2 in individual plots in 1985 and from 2 to 33% in 1986. Severities of leaf rust ranged from 1 to 22% in 1985 and from 2 to 40% in 1986. Yields of individual plots ranged from 3,986 to 5,076 hg/ha in 1985 and from 3,913 to 6,092 hg/ha in 1986. The effects of fungicide treatments on the severities of leaf rust and Septoria nodorum leaf blotch and on yield and TKW are presented in Tables 2 and 3. There were no significant effects of fungicide treatments on the severity of Septoria nodorum leaf blotch, but significant effects of fungicide treatments on the severity of leaf rust were found. Significant yield increases (563 hg/ha relative to unsprayed controls) were obtained in 1985 in plots treated at GS 7+9+10 and were associated with an increase in kernel weight (Table 2). In 1986, there were no significant effects of treatments on yield or kernel weight (Table 3).

Because mildew severities were low, regression analyses were not performed to determine potential relationships between the severity of mildew and severities of other diseases. Linear regressions were performed to determine relationships between Septoria nodorum leaf blotch and leaf rust. Significant linear relationships for regressions of Septoria nodorum blotch severity on leaf rust severity were determined for both years, and deviations were not significant (Table 1). Regression functions indicated inverse relationships between the severities of the two diseases in both years (Figs. 1 and 2). For the 1985 data, the following function

TABLE 1. Mean squares and associated degrees of freedom for analyses of variance for Septoria nodorum blotch severity for 1985 and 1986

Source	Degrees of freedom	Mean square[a] 1985	Mean square[a] 1986
Total	23	...	...
Replications	3	77.6	39.1
Treatments[b]	5	41.3	47.1
Linear	1	149.2*	222.1*
Deviation	4	14.3	53.6
Error	15	21.3	29.0

[a] * = Significant at $P \leqslant 0.05$.

[b] Treatment sums of squares are partitioned into sums of squares for regression on leaf rust severity and sums of squares for deviation.

TABLE 2. Effects of fungicide treatment on the severity of Septoria nodorum leaf blotch, leaf rust, yield, and thousand-kernel weight (TKW) in 1985

Treatment[w]	Septoria leaf blotch[x] (%)	Leaf rust[x] (%)	Yield[y] (kg/ha)	TKW (g)
Control	41.8	14.1 ab[z]	4,443 bc	36.4 b
GS 5	38.9	16.9 a	4,297 c	34.9 c
GS 7	40.7	9.4 b	4,531 bc	37.2 ab
GS 9	37.2	19.1 a	4,260 c	36.3 b
GS 7+9	43.4	10.1 b	4,670 ab	37.8 a
GS 7+9+10	46.1	8.6 b	5,006 a	38.0 a
LSD	ns	8.41	340	1.33

[w] Treatments consisted of foliar sprays of triadimefon (35 g a.i./ha) applied at indicated growth stages (GS).

[x] Data are the mean disease severities of the uppermost three leaves at GS 11.2.

[y] Yields are adjusted to 13% moisture.

[z] Values followed by the same letter are not significantly different according to the Waller-Duncan test (*k*-ratio = 100).

TABLE 3. Effects of fungicide treatment on the severity of Septoria nodorum leaf blotch, leaf rust, yield, and thousand-kernel weight (TKW)

Treatment[w]	Septoria leaf blotch[x] (%)	Leaf rust[x] (%)	Yield[y] (kg/ha)	TKW (g)
Control	5.6	32.3 a[z]	4,954	40.2
GS 5	7.7	21.2 ab	5,242	39.5
GS 7	7.1	21.7 ab	4,989	38.9
GS 9	12.3	7.0 bc	5,060	39.8
GS 7+9	11.9	3.7 c	4,546	40.1
GS 7+9+10	14.2	2.6 c	4,929	40.1
LSD	ns	14.69	ns	ns

[w] Treatments consisted of foliar sprays of fungicide (35 g a.i./ha) applied at indicated growth stages.

[x] Data are the mean disease severities of the uppermost three leaves at GS 11.2.

[y] Yields are adjusted to 13% moisture.

[z] Values followed by the same letter are not significantly different according to the Waller-Duncan test (*k*-ratio = 100); ns = not significant.

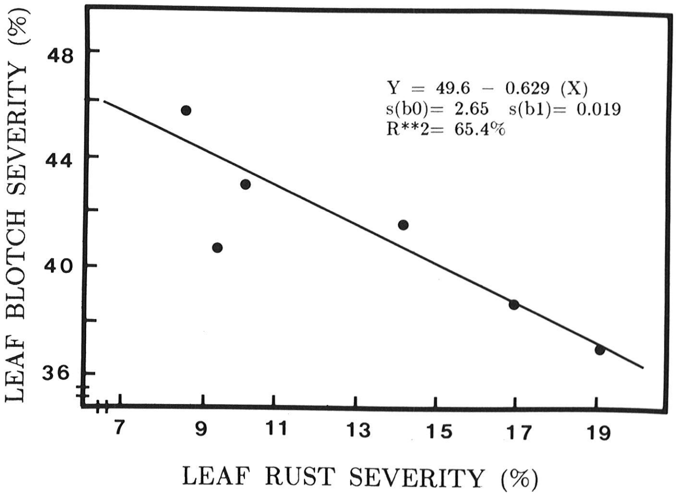

Fig. 1. Relationship between Septoria nodorum leaf blotch and leaf rust severities in 1985.

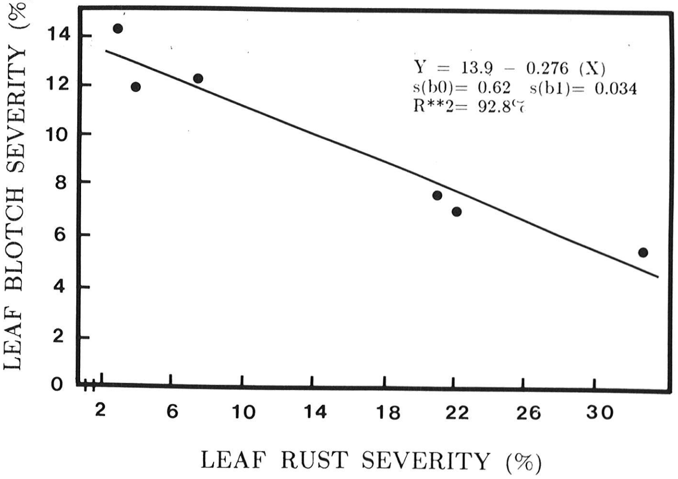

Fig. 2. Relationship between Septoria nodorum leaf blotch and leaf rust severities in 1986.

TABLE 4. Coefficients and *t* ratios for multiple regressions of yield on the severity of Septoria nodorum leaf blotch and leaf rust

	1985		1986	
Parameter	Coefficient	*t*-ratio[x]	Coefficient	*t*-ratio[x]
Intercept	5,260	6.62	4,322	11.67
% Septoria severity[y]	−6.4	−0.42	22.9	1.39
% Leaf rust severity[y]	−35.1	−2.33*	19.2	2.09*
F^*[z]	4.8*		2.23 ns	
r^2	24.9		10.0	

[x] *t* Ratio with 21 degrees of freedom. * = Significant at $P \leqslant 0.05$ and ns = not significant.

[y] Average percent severity of the uppermost three leaves at GS 11.2.

[z] *F* statistic with 2/21 degrees of freedom. * = Significant at $P \leqslant 0.05$.

was derived:

$$\%\ \text{septoria severity} = 49.6 - 0.629\ (\%\ \text{leaf rust severity}) \qquad r^2 = 0.654. \qquad (1)$$

For the 1986 data, the following function was derived:

$$\%\ \text{septoria severity} = 13.9 - 0.276\ (\%\ \text{leaf rust severity}) \qquad r^2 = 0.982. \qquad (2)$$

Multiple-regression analyses indicated that the diseases had little effect on yield (Table 4). In 1985, the regression of yield on disease severities was significant ($F^* = 4.80$) and *t*-ratios indicated that leaf rust was primarily responsible for yield loss. In 1986, the regression of yield on disease severities was not significant ($F^* = 2.23$).

DISCUSSION

The lack of control of Septoria nodorum leaf blotch by foliar application of triadimefon is consistent with previous observations, indicating that the fungicide has little activity against *L. nodorum* under field conditions (19). Leaf rust was affected by fungicide treatments, and yield increases were associated with certain treatments in 1985. Although leaf rust severities were generally higher in 1986 than in 1985, fungicide treatments did not affect yield. Insignificant effects of leaf rust on yield in 1986 are most likely due to the development of disease too late relative to host maturity to influence dry-matter accumulation.

Multiple-regression analyses indicated only a weak relationship between disease severities and yields of individual plots in 1985 and no significant relationship in 1986. In 1985, yield was statistically related only to the severity of leaf rust (Table 4). In this study, levels of disease severities may have been too low, or disease may have developed too late in the season relative to yield accumulation to affect yield.

The significant inverse relationships between Septoria nodorum leaf blotch and leaf rust are similar to those described for Septoria leaf blotch and powdery mildew (5,8). In both cases, specific reduction in the severity of a disease induced by an obligate parasite was associated with an increase in the severity of leaf blotch. Competition between the two pathogens for leaf tissue may account for the relationships observed but challenge the view of *L. nodorum* as a necrotrophic pathogen favored in stressed tissue (3,21).

Although fungicide treatment did not directly result in an increase in leaf blotch severity, results of regression analyses suggest that inverse interactions between the two pathogens exist and that such interactions should be considered in the evaluation of narrow-spectrum fungicides and of host resistance. These relationships may explain the results of fungicide-screening trials in which we have observed lower severities of Septoria leaf blotch in unsprayed controls than in certain fungicide treatments (20).

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