Control of *Septoria nodorum* on Wheat with Crop Rotation and Seed Treatment

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ABSTRACT

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Crop rotation and seed treatment were tested to determine their effects on disease development of glume blotch of wheat caused by *Septoria nodorum*. Crop rotation did not reduce disease development when infected seed was used. Seed treatment in conjunction with 1 yr of rotation did not significantly reduce disease development but seed treatment plus 2 yr of rotation reduced the amount of disease at all assessment dates. When uninfected seed was used, 1 or 2 yr of rotation significantly reduced disease development. A significant positive correlation between disease on the glumes and seed infection was found when disease severity was low (≤20%) but not when disease severity was high. A significant negative correlation between percent glume blotch and thousand kernel weight was observed when disease severity was low (≤20%).

Glume blotch, caused by *Septoria nodorum* (Berk.) Berk., is a major factor that limits profitable production of wheat in the southeastern United States. From 1971 to 1975, wheat acreage in Florida declined about 60%, with yields decreasing from 30 to 15 bu/acre (2,000–1,000 kg/ha). Most of the yield reduction was caused by glume blotch. A recent report indicated that reduction in grain yield of 30–50% can occur during severe epidemics in the United States (4).

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Attempts to find stable resistance have not been successful. Krupinsky et al (8) tested 6,000 wheats and selected 20 that were highly resistant. One of these (Hadden CI 13488) did not show adequate resistance when grown throughout the southeastern United States. Allingham and Jackson (1) tested 282 isolates of *S. nodorum* from Florida and found this species to have a wide range of virulence. More than 50% of their isolates were pathogenic on Moking (CI 12556), the most resistant cultivar selected by Krupinsky et al (8). Anderson (CI 12536) and Hadden (CI 13488), two resistant cultivars selected by Krupinsky et al (8), were found to be intermediate in reaction to *S. nodorum* by Rufty et al (11,12). Attempts to develop resistant cultivars have not been successful because of a wide range of virulence in the pathogen and lack of adequate resistance in the host.

Reports of the success of cultural practices for disease control were conflicting. Eyal (4) indicated that 3–5 yr of rotation were required to adequately reduce the severity of Septoria leaf blotch of wheat in Israel, but Rufty et al (11) reported that wheat straw infested with *S. nodorum* applied to test plots in November gave no more infection than the check.

Failure to find acceptable resistance to *S. nodorum* led to development of a chemical control method (9). Properly timed aerial applications of a zinc ion-maneb complex resulted in profitable increases in yield (9). Chemical control is expensive and will return a profit only when disease is severe and wheat prices are high. This led to a search for a system of cultural practice designed to reduce yield losses to an acceptable level. Our experiments were started because there is a need to control glume blotch and because of the lack of an adequate control system. This paper reports the effects of crop rotation, seed infection, and seed treatment on the severity of glume blotch of wheat.

MATERIALS AND METHODS

Crop rotation experiments were conducted in 1981 and 1982 at Gainesville, FL. A 2.5-acre area (1 ha) was divided into six main plots. Each main plot was 40 × 190 ft (12 × 63 m). The test plots, which were located in each main plot, were 4 × 12 ft (1.3 × 4 m). An 18-ft (6-m) buffer zone of rye was planted between test plots to reduce interplot infection. Three of the six main plots were used for the 1981 test and three for the 1982 test. The plots were arranged in a split-plot design with rotation as the whole plots and analyzed as a split plot according to the procedures of Snedecor and Cochran (14). Minimum differences for significance (Table 1) were obtained by means of the revised Duncan's ranges using for *P* only the maximum number of means to be compared (5). The cropping sequence consisted of 3 yr of continuous wheat (0-yr rotation), 2 yr of wheat followed by 1 yr of oats (1-yr rotation), and 1 yr of wheat followed by 2 yr of oats (2-yr rotation).

Three different seed treatments were used in each rotation treatment: uninfected seed, infected seed, and infected seed treated with benomyl. Infected seed and seed treated with benomyl were from the same seed lot harvested at Quincy, FL, in 1980. Benomyl was applied as a slurry at the rate of 8 oz/bu (0.2 g Benlate 50W/27 g seed). Seed infection was determined to be 40% with a method reported by Cunfer (2). Seed devoid of *S. nodorum* was obtained by treatment with benomyl dissolved in methylene chloride. This seed was then planted at Aberdeen, ID, in plots with ditch irrigation. *S. nodorum* was not found on seed obtained from Aberdeen. Four replicates of each of three seed treatments were used.

Tests were established after a summer crop of soybeans that was plowed under in September. Cultural and fertilizer practices recommended for wheat culture in Florida were used. The first test was planted on 20 November 1980. Rows were spaced 1 ft (0.35 m) apart. Coker 68-19 (CI 15229) wheat was seeded with a planter at the rate of 0.28 oz/ft of row (100 kg/ha). The plots for the 1982 test were planted on 16 November 1981. The disease assessment key developed by James (6) was used to estimate the amount of disease on the glumes, flag leaf (top leaf), second leaf, and third leaf. The amount of disease was estimated at different plant growth stages as described by Large (10). Twenty plants in each plot were evaluated on four dates.

RESULTS

Highly significant values for seed treatment effects and the seed treatment-rotation interaction were found (Table 2). The seed treatment-rotation interaction (Fig. 1) demonstrates that rotation had no effect on the percentage of disease when infected seed was used. Uninfected seed and benomyl-treated infected seed in conjunction with 2 yr of rotation greatly reduced the amount of disease.

One year of rotation did not significantly reduce the amount of disease when uninfected seed was used (Table 1). This trend was observed at all assessment dates except 26 March. Two years of rotation in conjunction with uninfested seed significantly reduced the amount of disease at all assessment dates. Neither 1 nor 2 yr of rotation significantly reduced the percentage of disease when infected seed was used, but 2 yr of rotation plus benomyl treatment significantly reduced the amount of disease at all assessment dates in 1982.

Values for correlation of percent glume blotch and percent seed infection were 0.10, 0.39, and 0.74 for the 0-yr, 1-yr, and 2-yr rotation treatments, respectively.

Table 1. Effects of crop rotation, seed infection, and seed treatment on development of *Septoria nodorum* on Coker 68-19 wheat at Gainesville, FL, in 1982

Assessment dates[a]	Seed treatments[b]	Years of rotation 0	1	2
16 March	Uninfected	5.5 (13.4)[c]	2.6 (8.7)	1.9 (5.5)
	Infected + benomyl	6.4 (14.5)	3.8 (10.3)	0.7 (4.3)
	Infected	7.1 (15.4)	5.8 (13.8)	5.3 (13.1)
26 March	Uninfected	34.6 (36.0)	26.5 (30.5)	14.6 (22.4)
	Infected + benomyl	36.3 (36.9)	28.8 (32.3)	23.8 (29.2)
	Infected	37.5 (37.7)	34.9 (36.2)	40.0 (39.1)
2 April	Uninfected	14.6 (22.3)	10.7 (18.7)	7.9 (16.1)
	Infected + benomyl	14.1 (21.8)	13.0 (21.1)	9.1 (17.0)
	Infected	15.8 (23.4)	13.1 (20.8)	21.6 (27.6)
16 April	Uninfected	25.2 (30.1)	19.8 (26.3)	13.9 (21.7)
	Infected + benomyl	27.5 (31.5)	25.1 (30.0)	18.1 (25.1)
	Infected	26.2 (30.8)	27.3 (31.4)	21.1 (28.0)

[a] Disease assessments were made on the head 16 April, on the first leaf 2 April, on the second leaf 26 March, and on the third leaf 16 March. Growth stages as described by Large (10) at these dates were 10, 10.1, 10.5, and 11, respectively.

[b] Uninfected seed was obtained from Aberdeen, ID. Seed 40% infected (infected seed) was obtained from Quincy, FL. Infected seed from Quincy was treated with 8 oz/bu (0.2 g/28 g) of benomyl 50W.

[c] Data are expressed in percentages using the assessment key developed by James (6) that designates the maximum amount of disease as 50%. Data in parentheses were transformed by arc sine before statistical analysis. Minimum differences for significance among any two transformed means were 4.8 and 6.4 at the 5 and 1% level, respectively (5).

Table 2. Mean squares, F values, and significance levels from the analysis of variance of the transformed percent disease showing the effects of rotation and seed treatment on Septoria glume blotch on Coker 68-19 Wheat in 1982

Source of variation	Degrees of freedom	Mean square	F values[z]
Rotation (R)	2	347.2	3.17
Replicate	3	50.9	0.46
Error a	6	109.7	...
Seed treatment (ST)	2	367.1	48.37**
ST × R	4	100.3	13.22**
Date (D)	3	3,400.2	447.99**
D × R	6	18.9	2.50*
D × ST	6	21.7	2.86*
D × St × R	12	7.2	0.97
Error b	99	7.6	...

[z] Transformed percent disease data were used for the analyses of variance. * = F value significant at the 5% level and ** = F value significant at the 1% level.

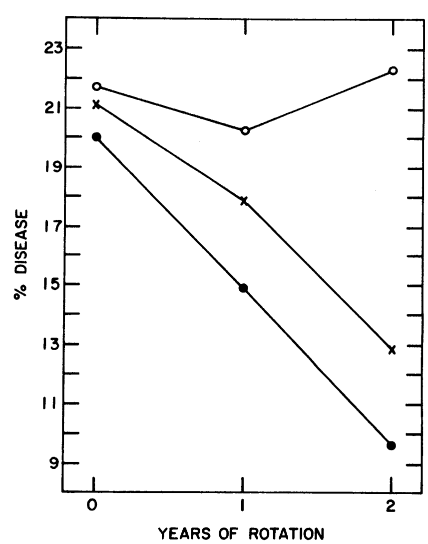

Fig. 1. The effects of crop rotation and seed treatments on the development of *Septoria nodorum* on wheat. Infected seed (o), uninfected seed (•), infected seed treated with benomyl (X). Each data point consists of 320 assessments.

Values for correlation of percent glume blotch and thousand kernel weight (TKW) were −0.09, −0.55, and −0.87 for the 0-yr, 1-yr, and 2-yr rotation treatments, respectively. Correlation values for percent seed infection and TKW were −0.21, −0.64, and −0.76 for the 0-yr, 1-yr, and 2-yr rotation treatments, respectively. In each rotation treatment, 180 heads were assessed for percent disease and 900 seeds were tested for percent seed infection. Percent glume blotch from the 0-yr, 1-yr, and 2-yr rotation treatments was 26, 24, and 18%, respectively, and percent seed infection was 19, 19, and 13%, respectively.

The data from the 1981 test were not presented because dry weather retarded development of the epidemic. The maximum amount of disease in 1981 was ≤5%.

DISCUSSION

The influence of crop rotation on development of *S. nodorum* on wheat has not been studied in detail. Our results (Table 1) show that 1 yr of rotation did not significantly (1% level) reduce the amount of disease when uninfected seed was used. Therefore, 1 yr of rotation where wheat follows soybeans may not effectively reduce the amount of glume blotch. Our results indicated that neither 1 nor 2 yr of rotation significantly reduced the amount of disease when infected seed was used. Rotation therefore may not be of much value when the percentage of seed infection is high and weather conditions favor disease development. Pathogen-free seed and infected seed treated with benomyl significantly reduced the amount of disease when used in conjunction with 2 yr of rotation. Spring of 1982 was very favorable for development of glume blotch. When conditions were favorable for infection, 2 yr of rotation plus seed treatment were required to significantly reduce development of glume blotch. In 1981, March and April were dry and the epidemic did not develop. The maximum disease severity was ≤5%; therefore, there were no significant differences among treatments.

The results of Rufty et al (12) indicated that infested straw did not have much influence on disease development. Our results show that debris from previous crops influenced the amount of disease after 2 yr of rotation. This observation is similar to a report indicating that 3–5 yr of rotation were needed to decrease the incidence of *S. tritici* in Israel (4). Our results cannot be compared with those of Rufty et al (12) because they applied infested straw at different time intervals and we harrowed in the unharvested wheat crop and planted soybeans. Nevertheless, we believe that debris from the previous wheat crop is an important inoculum source in Florida.

Several reports indicated that mercury seed treatments of infected seed increased germination and decreased seedling infection caused by *S. nodorum* (7,13,15). Jenkyn and King (7) reported a decrease in the percentage of infection of the flag leaf sheath when infected seed had been treated with Agrosan GN (1% organically combined mercury). Our results indicate that benomyl seed treatment did not significantly reduce disease development in the 0- and 1-yr rotation plots but significantly reduced the amount of disease in the 2-yr rotation plots. Our results were obtained during a severe epidemic of Septoria glume blotch in 1982. We conclude that benomyl seed treatment in conjunction with 2 yr of rotation would give acceptable disease control under most conditions in Florida.

A recent study of the relationship between glume blotch and seed infection indicated that all correlations were not significant from zero (3). We also found that r values for the 0- and 1-yr rotation treatments were not significant from zero, but the r value (0.74) for the 2-yr rotation treatment was significant from zero at the 5% level. The development of the epidemic was retarded in the 2-yr rotation treatment and the range in percent glume blotch was relatively narrow (8–25%). Late head infection and the narrow range in percent glume blotch may explain the significant correlation between seed infection and glume blotch in our 2-yr rotation treatment.

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