Integrated Management of Septoria Blotches of Wheat: Effects of Stubble Management, Rotation, Nitrogen Level and Variety

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Abstract

The influence of rotation, residue management, nitrogen fertilizer levels and varieties on the onset, development and severity of Septoria blotches and kernel weight and yield of wheat was studied at two environments, Ambo and Holetta. One—or two—years rotation of wheat with faba bean and/or 'gomenzer' or burning crop residues delayed the onset of Septoria blotches and, consequently, increased wheat yield. The diseases started early on the current crop when stubble from previous season were retained or partially removed. However, the progress of the diseases, once started, was not consistent among the rotation and residue management treatments. Nitrogen fertilizer levels had no effect on Septoria blotches, but higher rate increased wheat yield significantly. Wheat varieties were consistent in their reactions to the onset, progress and severity of Septoria blotches and yields. This suggests that the use of resistant varieties of wheat plays the most important role in the management of Septoria blotches. Although significant interaction among the treatments was not obtained, the results revealed that combining the use of resistant varieties with either faba bean or 'gomenzer' rotation greatly reduced the threat of Septoria blotches on wheat production.

Key word: Integrated management, Septoria blotches, wheat

Introduction

Septoria blotches of wheat incited by *Mycosphaerella graminicola* (Fuckel) Sand (anamorph *Septoria tritici* Rob. in Desm.) and *Phaeosphaeria nodorum* (=*Leptosphaeria nodorum* Muller; anamorph *Stagonospora nodorum* or *Septoria nodorum* (Berk) Berk) occur worldwide in wheat often attaining epidemic proportion and causing significant reduction in yield (Eyal et al. 1987). Septoria blotches are among the major diseases of wheat in Ethiopia limiting the production of the crop in many areas particularly where the crop is grown under improved practices (Eshetu 1985, Mengistu et al. 1991). The primary inocula for these diseases are most often air–borne ascospores, but may also be wind-and rain-borne conidia (Scharen 1999). Residue (stubble) from wheat crop of the previous season then plays a major role in the survival and development of ascospores (Milus and Chalkley 1997). Krupinsky (1999) reviewed several cultural practices that could influence the survival and production of the primary inoculum of Septoria/Stagonospora species on residues of the previous crop season. Appropriate crop rotations, plowing and burning crop residues of previous wheat crop and application of correct amount of nitrogen fertilizer were reported to reduce the severity of the diseases. The integrated effects of sowing dates, varieties and fungicides were studied previously under Holetta and Ambo conditions where Septoria/Stagonospora diseases are often very severe and moderate, respectively

(Eshetu and Zerihun 2003). This study was a continuation of the previous study undertaken to investigate the effects of the integration of rotation, residue management, nitrogen fertilizer levels and varieties on Septoria/Stagonospora blotches development and grain yield.

Materials and Methods

The experiment was carried out at Holetta and Ambo research centers where severe and moderate levels of Septoria blotches, respectively, develop every year. The layout of the experiment was a split-split plot arrangement in a randomized complete block design with rotation/residue management, nitrogen fertilizer levels and varieties as main, sub and sub-sub plot treatments, respectively. The main plot treatments (rotation and residue management) used in each season are presented in Table 1. The whole plot was sown with a susceptible wheat variety HAR710 in 1997 to get uniformly distributed Septoria infected residues to begin with the trial in the consecutive seasons. Faba bean variety CS20DK and gomenzer (*Brassica carinata*) variety Yellow Dodolla were used as one or two years rotation crops with wheat. The last three treatments were the different residue managements where wheat varieties were sown each year after the stubble of the previous wheat crops was burned (WSB), retained (WSR) or partially removed (WSPR). The last treatment (WSPR), where the stubble was partially removed by hand, could be considered as a control since it simulates the farmers' practice in which the wheat stubble is usually grazed by animals without completely removing it. The main plots were fixed throughout the experiment period. The sub-plot treatments were nitrogen fertilizer levels with 30kg/ha (N1) to represent the low nitrogen level that farmers usually use and 60 kg/ha (N2), which is the recommended amount of nitrogen for the two locations. The nitrogen fertilizer was applied in the form of urea. A blanket application of the recommended rate of P_2O_5 (26 kg ha^{-1}) at both locations, in the form of diammonium phosphate (DAP), was also made at planting with each nitrogen level. The nitrogen content in the DAP was also considered in the above N levels.

Table 1. Main plot treatments (rotation and crop residue management) used in the integrated management study of Septoria blotches of wheat, 1997-2001

Treatment	Cropping Seasons				
	1997	1998	1999	2000	2001
WFWFW	Wheat	Faba bean	Wheat	Faba bean	Wheat
WGWGW	Wheat	Gomenzer	Wheat	Gomenzer	Wheat
WGFWW	Wheat	Gomenzer	Faba bean	Wheat	Wheat
WFGWW	Wheat	Faba bean	Gomenzer	Wheat	Wheat
WSB	Wheat	Stubble burned + wheat	Stubble burned + wheat	Stubble burned + wheat	Stubble burned + wheat
WSR	Wheat	Stubble retained + wheat	Stubble retained + wheat	Stubble retained + wheat	Stubble retained + wheat
WSPR	Wheat	Stubble partially removed + wheat	Stubble partially removed + wheat	Stubble partially removed + wheat	Stubble partially removed + wheat

The sub-sub plot treatments were wheat varieties that included the moderately resistant HAR604 (V1), the moderately susceptible HAR1685 (V2) and the susceptible HAR710 (V3). The sub-sub plots were 3 m x 3 m in size and the experiment was done in three replications. Planting dates and other cultural practices were used as recommended to Ambo and Holetta centers.

Septoria blotches were recorded as the first disease appearance (the number of days between planting i.e., and the first symptom of Septoria blotch observed), disease scores using the modified double-digit 00-99 scoring scale at 10 to 15 days interval to determine vertical progress and severity of the disease (Eyal et al. 1987). The two digit scores were taken as the numerical disease description and used for statistical analysis. Disease severity was also recorded on 25 randomly collected flag leaves per sub-sub plot at about mid dough stage of the crop and rated on a 0 to 5 scale in which 0 = no lesion and 5 = the whole leaf blighted. Seed weight and yield were also taken at harvest. All the disease and yield data of the 2000 and 2001 seasons were analyzed using the GLM procedure of SAS, Version 8.2. The data of the two locations were not combined for analysis due to lack of homogeneity of error variance using Bartlett's test and observing the deviation of error mean squares.

Results

Stubble management and rotation significantly influenced the onset of Septoria blotches at Holetta (Table 2). The disease appeared early, 22 days after planting, when wheat residues from the previous seasons were retained or partially removed and it took longer (27 days) for the disease to appear when the residues were burnt. Rotation with faba bean and gomenzer also prolonged the onset of the disease to 25 and 24 days, respectively. Stubble management and rotation differed significantly, but not consistently, in first, last and mean Septoria scores on the 00-99 scoring scale which measured the disease progress in the growing season. Flag leaf ratings for disease severity was considerably low when wheat was planted with faba bean in alternative seasons. Kernel weight was significantly low in the second wheat crop in 2001, after two years of rotation with faba bean and gomenzer, as compared to when the stubble was burned or partially removed. Yield of wheat was significantly high (38 q/ha) when grown in rotation with gomenzer every other year. One year rotation with faba bean or two years rotation with gomenzer and faba bean also gave high yield as compared to residue management treatments.

The two nitrogen levels did not significantly influence Septoria blotches and kernel weight (Table 2). However, the higher level of nitrogen had greatly increased grain yield to 31q/ha as opposed to 25 q/ha of the lower rate.

Varieties significantly differed in disease appearance and progress as well as in kernel weight and yield (Table 2). The variety HAR 604 exhibited significantly lower level of the disease and higher seed weight and yield than to HAR710. The variety HAR1685 generally behaved in between the two in disease progress and severity and in kernel weight and yield.

Table 2. Main effect of management, nitrogen levels and variety on Septoria blotches and yield of wheat at Holetta, 2001

Treatment	Septoria blotches assessments[2]					KW	Yield
	DA	FS	LS	MS	FL	(g)	(q/ha)
Management[1]							
WFWFW	25.2	34.7	83.7	65.9	4.4	34.1	33.0
WGWGW	24.2	33.6	84.4	66.6	4.5	34.0	38.1
WGFWW	20.4	34.4	83.9	66.2	4.6	34.3	30.5
WFGWW	20.5	36.9	84.1	67.7	4.6	33.2	27.1
WSB	26.9	34.8	81.1	65.5	4.5	35.1	25.1
WSR	22.2	32.2	84.4	64.8	4.7	34.5	20.9
WSPR	22.1	29.2	84.1	64.3	4.6	35.2	22.7
LSD ($p \leq 0.05$)	1.06	4.21	0.54	1.96	0.28	1.33	3.12
Nitrogen							
N1	23.1	33.7	83.6	65.8	4.6	34.2	25.4
N2	23.0	33.7	83.7	65.9	4.5	34.5	30.6
LSD ($p \leq 0.05$)	ns	ns	ns	ns	ns	ns	1.67
Variety							
HAR604	22.8	19.5	77.6	56.1	4.0	38.4	32.0
HAR1685	24.1	34.4	86.3	67.0	4.8	33.9	30.2
HAR710	22.4	47.2	87.1	74.4	4.8	30.7	22.4
LSD ($p \leq 0.05$)	0.70	2.75	1.41	1.28	0.19	0.87	2.05

[1] See Table 1 for treatments;

[2] DA = disease appearance (days after planting); FS = first Septoria score on 00-99 scale (67 days after planting); LS = last Septoria score on 00-99 scale (109 days after planting); MS = mean Septoria score on 00-99 scale (mean of 4 fortnightly taken scores); FL = Flag leaf rating on 0-5 scale; KW = 1000 kernel weight.

Similar results were obtained at Ambo in 2001 although the disease onset took longer and disease scores were lower at Ambo than at Holetta (tables 2 and 3). This indicates that Septoria blotches are more severe at Holetta than Ambo. The disease appearance on wheat planted in rotation with faba bean and gomenzer, except on treatment WGFWW for a reason not clear, took longer time (40 to 42 days) than the stubble management treatments (Table 3). First 00-99 Septoria score was significantly lower when the stubble from the previous season was burned about three months before planting. However, stubble management and rotation treatments were not different from each other in the latter scorings. Grain yield of wheat was higher when planted in rotation with either faba bean (24 q/ha) or gomenzer (23 q/ha) as compared to stubble management treatments (18 q/ha to 19 q/ha). Kernel weight was not significant among all stubble management and rotation treatments.

Similar to the results of Holetta, the different nitrogen levels did not influence the onset, progress and severity of the disease as well as the kernel weight (Table 3). However, yield was significantly increased by the higher rate of nitrogen fertilizer.

Table 3. Main effect of management, nitrogen levels and variety on Septoria blotches and yield of wheat at Ambo, 2001

Treatment	Septoria Blotches Assessments[2]				KW (g)	Yield (q/ha)
	DA	FS	LS	MS		
Management[1]						
WFWFW	41.8	13.9	54.3	34.9	31.7	23.9
WGWGW	40.1	13.9	53.8	34.9	32.4	22.7
WGFWW	38.5	16.2	56.8	37.2	30.6	20.3
WFGWW	40.5	16.2	54.9	36.7	30.7	18.7
WSB	39.1	12.1	52.1	32.9	31.6	17.9
WSR	39.9	13.3	53.1	34.7	30.9	18.4
WSPR	39.9	13.8	52.5	33.9	31.9	19.2
LSD ($p \leq 0.05$)	1.60	2.75	ns	ns	ns	2.78
Nitrogen						
N1	39.9	14.1	54.0	35.1	31.3	19.2
N2	40.0	14.3	53.8	35.0	31.5	21.1
LSD ($p \leq 0.05$)	ns	ns	ns	ns	ns	1.49
Variety						
HAR604	39.8	12.7	50.9	32.0	32.4	19.5
HAR1685	40.6	12.2	52.0	32.9	32.7	22.1
HAR710	39.5	17.7	58.9	40.3	29.1	18.7
LSD ($p \leq 0.05$)	ns	1.80	3.25	2.66	1.28	1.82

[1] See Table 1 for treatments;

[2] DA = disease appearance (days after planting); FS = first Septoria score on 00-99 scale (67 days after planting); LS = last Septoria score on 00-99 scale (109 days after planting); MS = mean Septoria score on 00-99 scale (mean of 4 fortnightly taken scores); FL = Flag leaf rating on 0-5 scale; KW = 1000 kernel weight.

Septoria blotches appeared at about the same time on all the varieties at Ambo (Table 3). Disease progress and severity were similar on varieties HAR604 and HAR1685 and were significantly lower than that of HAR710. The variety HAR1685 yielded more than the others at Ambo.

It should be noted that in the rotation treatments WGFWW and WFGWW, the plots were planted with wheat consecutively in 2000 and 2001 seasons after two years rotation with gomenzer and faba bean or faba bean and gomenzer (Table 1). Hence, the wheat crop in 2001 season was a second continuous wheat crop and the effect of the two-years rotation could not be realized. When wheat was planted immediately after the two years rotations with either gomenzer–faba bean or faba bean–gomenzer in 2000 season, the onset of the blotches was significantly delayed and the yield increased at Holetta (Table 4). At Ambo the severity of the disease on the flag leaf was reduced and yield increased (Table 5). The results also indicated that wheat yield was lower when planted after gomenzer than when planted after faba bean, although the effect on Septoria blotches was not clear.

Table 4. Main effect of management, nitrogen levels and variety on Septoria blotches and yield of wheat: Holetta, 2000

Treatment	Septoria Blotches Assessments[2]					KW	Yield
	DA	FS	LS	MS	FL	(g)	(q/ha)
Management[1]							
WFWFW	-	-	-	-	-	-	-
WGWGW	-	-	-	-	-	-	-
WGFWW	32.6a	38.6	84.2	60.3	4.2	20.3	20.3
WFGWW	31.8	38.3	84.6	60.6	4.3	21.4	18.3
WSB	30.7	38.2	83.9	60.2	4.1	22.9	17.9
WSR	26.1	38.4	85.3	60.2	4.2	23.2	15.9
WSPR	25.4	38.2	83.8	60.5	4.2	25.3	20.5
LSD ($p \leq 0.05$)	1.16	ns	ns	ns	ns	1.57	2.33
Nitrogen							
N1	29.1	38.4	84.5	60.6	4.1	22.8	17.3
N2	29.6	38.3	84.2	60.2	4.3	22.4	20.0
LSD ($p \leq 0.05$)	ns	ns	ns	ns	ns	ns	1.48
Variety							
HAR604	29.5	31.5	72.3	51.4	3.0	25.3	21.6
HAR1685	30.0	41.6	90.8	64.5	4.9	21.6	18.5
HAR710	28.5	41.9	90.0	65.1	4.8	20.9	15.9
LSD ($p \leq 0.05$)	0.90	0.34	1.28	0.80	0.27	1.21	1.81

[1] See Table 1 for treatments;

[2] DA = disease appearance (days after planting); FS = first Septoria score on 00-99 scale (67 days after planting); LS = last Septoria score on 00-99 scale (109 days after planting); MS = mean Septoria score on 00-99 scale (mean of 4 fortnightly taken scores); FL = Flag leaf rating on 0-5 scale; KW = 1000 kernel weight.

Discussion

The survival of Septoria blotches on residue from a previous wheat crop is the most important means of carryover from one crop to the next (Krupinsky 1999). Proper crop rotations in combination with other practices are thus recommended to reduce the severity of the diseases. The result of the current study indicated that one-or two-years rotations of wheat crop with faba bean and/or gomenzer to delay the onset of Septoria blotches and, consequently; increase yield of wheat. The diseases start early on the current crop when stubble from wheat grown in the previous season was retained or partially removed. However, the influence of rotation or stubble management on the progress of the disease, once it started, was not consistent.

Burning the residue from the previous heat crop also delayed the start of Septoria 6 lotches on the current crop as much as the rotation treatments did. However, burning may not be hot enough to eliminate all residues, leaving sufficient infected residue as source of inocula for the next wheat crop (Eyal 1981). Moreover, although burning crop residue was recommended in the past, it is no longer recommended because of environmental concerns (Krupinsky 1999).

Table 5. Main effect of management, nitrogen levels and variety on Septoria blotches and yield of wheat: Ambo, 2000

Treatment	Septoria Blotches Assessments[2]					KW	Yield
	DA	FS	LS	MS	FL	(g)	(q/ha)
Management[1]							
WFWFW	-	-	-	-	-	-	-
WGWGW	-	-	-	-	-	-	-
WGFWW	54.6	22.4	74.3	48.8	2.6	32.8	33.8
WFGWW	55.1	21.9	75.4	48.6	2.8	32.9	28.7
WSB	55.7	21.9	76.0	48.8	3.1	31.8	26.2
WSR	54.5	23.2	77.8	50.6	3.2	31.7	23.7
WSPR	55.5	23.8	77.8	50.8	3.4	31.6	24.9
LSD ($p \leq 0.05$)	ns	ns	ns	ns	0.23	ns	2.17
Nitrogen							
N1	55.2	23.0	76.5	49.8	3.1	31.5	24.4
N2	54.9	22.3	76.0	49.3	2.9	32.8	30.5
LSD ($p \leq 0.05$)	ns	ns	ns	ns	0.15	0.92	1.37
Variety							
HAR604	55.9	19.2	67.9	43.8	2.4	32.1	26.8
HAR1685	55.9	18.8	75.6	46.1	2.5	34.4	30.5
HAR710	53.4	29.9	85.2	58.8	4.1	29.9	25.0
LSD ($p \leq 0.05$)	1.09	2.14	2.07	1.85	0.18	1.13	1.68

[1] See Table 1 for treatments;

[2] DA = disease appearance (days after planting); FS = first Septoria score on 00-99 scale (67 days after planting); LS = last Septoria score on 00-99 scale (109 days after planting); MS = mean Septoria score on 00-99 scale (mean of 4 fortnightly taken scores); FL = Flag leaf rating on 0-5 scale; KW = 1000 kernel weight.

Howard (1996) reported that the severity of foliar diseases increased on winter wheat with higher nitrogen rates. Huber et al. (1987), on the other hand, showed that severity of tan spot, another foliar disease of wheat, decreased and yield increased as the nitrogen rate increased. In a review of the influence of cultural practices on Septoria/Stagonospora diseases, Krupinsky (1999) stated that there have been many cases where the disease severity increases, decreases or no effect with increasing nitrogen rates depending on regions and environments. In the current study, both of the nitrogen fertilizer levels could not influence the onset, progress or severity of the diseases. The recommended nitrogen level, however, increased grain yield significantly over the lower rate.

The performances of the wheat varieties were more consistent than the stubble management, rotation and nitrogen treatments to show significant differences in the progress of the diseases, kernel weight and grain yield. The disease often started early, progressed faster and consequently lowered the seed weight and yield of the variety HAR710. The use of resistant or tolerant varieties then played the major role in the management of Septoria blotches (Eshetu et al. 2003). There was no significant interaction between treatments that influenced the

disease development or the yield, except that HAR1685 yielded significantly more at Ambo. However, it can be concluded that integrating resistant or tolerant wheat varieties with one-or two-years rotation with faba bean and/or gomenzer at the recommended fertilizer level greatly reduces the threat of Septoria blotches and, consequently, increases yield of wheat in disease–prone areas.

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