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Field Response of Wheat Genotypes to Septoria Tritici Blotch In Tigray, Ethiopia

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Abstract
Septoria tritici blotch is an economically important foliar disease in the major wheat-growing areas of Ethiopia. Genetic resistance remains the first line of defense against this foliar disease, especially in developing countries for resource poor farmers and the most environmentally friendly and profitable strategy for commercial farmers. Hence, screening of host plant resistance against Septoria tritici blotch was the prime objective this study. A total of 200 bread wheat lines, commercial and candidates of bread and durum varieties were included in the evaluation. The study revealed that none of the genotypes were immune. The majority (75.5%) of the wheat genotypes were vulnerable to the disease and classified as susceptible to highly susceptible infection response. About 12% of the genotypes were moderately susceptible. The remaining limited genotypes (12.5%) were within the range of highly to moderately resistant. Therefore, incorporating of host plant resistant (gene pyramiding) in breeding programme could be utmost important for narrowing the potential and actual yield gabs along with study of pathogen structure.
Key words: Bread, Durum, Genotype, Septoria tritici blotch, Wheat

Introduction

Wheat (Triticum spp.) belongs to the four most important cereal crops in modern agriculture (htt://www.faostat.org). The FAO estimates that 682.5millon tone of wheat was harvested in the year 2011. Bread wheat accounts for approximately 20% of the totally consumed human food calories and provides the most stable food for 40% of the human population. In Ethiopia, cereals constitute about 82% of the area and 87.3% of the production devoted to major crops (CSA, 2013). Among the cereals, wheat is an important crop and widely cultivated in a wide range of altitude (Hailu, 1991). Ethiopia is the second largest producer of wheat only after South Africa in Sub-Saharan Africa. During the last 15 years the area covered by wheat has increased from 0·77 million ha in 1997 to 1.7 ha million ha in 2013, and it now ranks fourth among the crops next to tef (Eragrostis tef), maize (Zea mays L), and Sorghum (Sorghum bicolar L) (CSA, 1998, 2013). In spite of the production and yield increases, average grain yield of wheat is still low (<2.4 t/ha) and highly variable and below the world's average (3.3 t/ha) (FAO, 2007).

The low productivity is attributed to a number of factors including biotic and abiotic as well as low adoption of new agricultural technologies (Zegeye et al., 2001). Of the biotic stress, diseases caused by fungi are among the most important constraining wheat production. Yellow rust (Puccinia striiformis f.sp. tritici), stem rust (P. graminis f.sp. tritici), leaf rust (P. triticina) and Septoria diseases especially Septoria tritici blotch is prevalent throughout the country (Eshetu, 1985). Septoria tritici blotch (STB), caused by the fungus Septoria tritici, is a major disease of wheat in all wheat-growing areas of the world, and the cause of yearly serious economic losses (Eyal, 1999; Ramdani et al., 2011). Septoria tritici blotch is a major disease of wheat in all wheat-growing areas of Ethiopia, causing serious yearly economic losses (up to 82%) (Getinet et al., 1990; Mengistu et al., 1991; Ayele et al., 2008). Currently, it is among the top two or three most economically damaging diseases of this crop in the Tigray region (Mekelle Research Center, 2005; Ayele et al., 2008; Teferi and Gebreslassie, 2015). Control of the disease is by fungicides or cultural practices and, when possible, by resistant cultivars. Planting of resistant cultivars is the most economical and simple approach for managing Septoria tritici blotch. Resistance in wheat to Septaria tritici has been demonstrated by a number of researchers, and breeding for resistance is likely to be the most practical method of control (Arama, 1996). Several sources of resistance have been reported but breeding for resistance has not always been successful in protecting wheat cultivars from the damaging effects of the disease, because expression of resistance is often correlated with morphological traits (Eyal et al., 1985). Moreover, wheat cultivars resistant in one part of the world may display susceptibility elsewhere. Even within country, differences observed in virulence may be associated with fungal genetic variability (Eyal et al., 1985). The currently grown high yielding wheat cultivars are more susceptible to Septoria tritici blotch and utilization of sources of resistance is of a high priority in national and international breeding programs. Thus, the objective of this study was to evaluate the response of wheat genotypes against the prevailing Septaria tritici population.

Material and methods

Discretion of the study area

The study was carried out in Ofla district, Tigray, Ethiopia, located at 12^{o}31'N latitude and 39^{o}33'E longitude and an elevation of 2490 meter above sea level. The annual rainfall varies from 450 to 1200 mm during summer (June to September). The mean annual temperature is 22^{o}c with minimum and maximum temperature of 6^{o}c and 30^{o}c, respectively.

Screening resistance to Septoria tritici blotch

The experiments were conducted in the main cropping season of 2014 (June to September). Included entries were 200 (86 bread wheat lines, 25 nationally released bread wheat varieties, and 89 commercial and candidate varieties of both durum and bread wheat). The 86 bread wheat lines and 25 commercial or nationally released bread wheat varieties were arranged in Alpha lattice design with three replications at four experiments. Two standard varieties (Hidasse and Ogolcho) were used in each experiment. Each variety was planted in a plot consisting of six rows of 2.5 m long spaced at 20 cm between rows. In addition, a trap nursery consisting of 89 entries were evaluated in single plot each in two row of 1m length and spaced 20cm far apart. Three entries (Morocco, PWB343 and Enkoy) were in every 20 entries served as checks. A seed rate of 150 kg ha^{-1} and fertilizer rates of 64 and 46 kg ha^{-1} N and P_2O_5, respectively, were applied to all experiments. Data were collected on plot basis from the central four rows for the four experiments and the two rows for the trap nursery. The scoring were made when the crop growth stage (GS) was made on average at early maturity stages according to Zadoks et al., (1974). The severity of Septoria tritici blotch was examined using the double-digit scale (00–99) developed as a modification of Saari and Prescott's severity scale to assess wheat foliar diseases (Saari and Prescott, 1975; Eyal et al., 1987). The first digit (D1) indicates vertical disease progress on the plant and the second digit (D2) refers to severity measured as diseased leaf area. Percent disease severity is estimated based on the formula: % severity = ((D1/Y1) x (D2/Y2) x 100), where D1 and D2 represent the score recorded (00-99 scale) and Y1 and Y2 represent the maximum score on the scale (9 and 9) (Sharma and Duveiller, 2007). Then, genotypes were classified in seven categories; immune (00), highly resistant (11-14), resistant (15-34), moderately resistant (35-44), moderately susceptible (45-64), susceptible (65-84) and highly susceptible (85-99) (Eyal et al., 1987).

Results and Discussion

Use of resistant variety is the best control strategy of fungal diseases in general and Septoria tritici blotch in particular for resource poor farmers in developing countries and the most environmentally friendly and profitable strategy for commercial farmers. According to van Ginkel et al., (1999), in most wheat production environments, although not in all, genetic resistance is the most economical approach to control fungal diseases besides to cultural and chemical that may be utilized. Hence, this study was carried out aiming at screening of wheat genotypes including bread wheat lines, candidate and commercial wheat types for Septoria tritici blotch resistance and/or tolerance. Accordingly, 86 bread wheat lines (Table 1), 25 nationally released bread wheat varieties (Table 2), 89 commercial and candidate varieties of bread and durum wheat (Table 3 and 4) were evaluated against Septoria tritici blotch under natural epidemics. The results on disease intensity and host response are presented in Tables 1, 2, 3 and 4. Surprisingly, this study confirmed that none of the wheat genotypes were completely resistance or immune to Septoria tritici blotch (Tables 1, 2, 3 & 4). For this reason, where resistance is not effective, tolerance can be sought according to McKendry and Henke, (1994). Out of 86 bread wheat lines, only one (ETBW 6940) was exhibited highly resistant to the pathogen. Similarly, limited number of bread wheat lines; six (ETBW 7809, ETBW 7120, ETBW 8493, ETBW 8495, ETBW 8497 and ETBW 8501), two (Hidasse and ETBW 8513) and nine (ETBW 7588, ETBW 8511, ETBW 7147, ETBW 8503, ETBW 7547, ETBW 8462, ETBW 7213, ETBW 7808 and ETBW 6937) were found resistant, moderately resistant and moderately susceptible against the disease, respectively (Table 1). These few genotypes with tolerance characteristics could be considered in breeding program and an important component in intergraded management of Septoria tritici blotch in the region.

Conversely, 50% of the bread wheat lines sustained maximum infection level of 85-99 and with highly susceptible reaction. Likewise, about 29% of the bread lines expressed susceptible reaction to the disease (Table 1). This indicated that Septoria tritici blotch is one of the devastating diseases that curtail the production and productivity of wheat nationwide as 79.1% bread wheat lines were within the range of susceptible to highly susceptible reactions.

Table 1. The response of wheat bread lines for Septoria tritici blotch in 2014

Genotype	Severity		Response	Genotype	Severity		Response	Genotype	Severity		Response
	00-99	%			00-99	%			00-99	%	
Hidasse	43	14.81	MR	Ogolcho	86	59.26	HS	ETBW 6861	74	34.57	S
ETBW 7392	74	34.57	S	ETBW 7442	65	37.04	S	ETBW 8506	67	51.85	S
ETBW 7414	96	66.67	HS	ETBW 7446	87	69.14	HS	ETBW 8507	87	69.14	HS
ETBW 7452	98	88.89	HS	ETBW 7547	64	29.63	MS	ETBW 7120	32	7.41	R
ETBW 7513	86	59.26	HS	ETBW 8461	87	69.14	HS	ETBW 8508	88	79.01	HS
ETBW 7588	64	29.63	MS	ETBW 8462	53	18.52	MS	ETBW 7213	75	43.21	S
ETBW 7592	97	77.78	HS	ETBW 7587	75	43.21	S	ETBW 8509	74	34.57	S
ETBW 7644	78	69.14	S	ETBW 7598	88	79.01	HS	ETBW 7038	75	43.21	S
ETBW 7853	96	66.67	HS	ETBW 8463	75	43.21	S	ETBW 8510	66	44.44	S
ETBW 7863	98	88.89	HS	ETBW 7610	97	77.78	HS	ETBW 7058	95	55.56	HS
ETBW 7898	74	34.57	S	ETBW 7613	97	77.78	HS	ETBW 8511	53	18.52	MS
ETBW 7809	31	3.70	R	ETBW 7634	64	29.63	MS	ETBW 7147	63	22.22	MS
ETBW 8489	75	43.21	S	ETBW 7637	95	55.56	HS	ETBW 8512	87	69.14	HS
ETBW 8490	96	66.67	HS	ETBW 7639	76	51.85	S	ETBW 7871	75	43.21	S
ETBW 8491	74	34.57	S	ETBW 7808	64	29.63	MS	ETBW 8513	42	19.88	MR
ETBW 8492	88	79.01	HS	ETBW 7847	97	77.78	HS	ETBW 6940	12	2.47	HR
ETBW 8493	33	11.11	R	ETBW 7919	87	69.14	HS	ETBW 8514	98	88.89	HS
ETBW 8494	74	34.57	S	ETBW 7920	75	43.21	S	ETBW 7368	65	37.04	S
ETBW 8495	21	2.47	R	ETBW 7887	96	66.67	HS	ETBW 8515	97	77.78	HS
ETBW 8496	75	43.21	S	ETBW 8464	96	66.67	HS	ETBW 7364	97	77.78	HS
ETBW 8497	31	3.70	R	ETBW 7630	97	77.78	HS	ETBW 8516	87	69.14	HS
ETBW 8498	75	43.21	S	ETBW 7550	96	66.67	HS	ETBW 7194	65	37.04	S
ETBW 8499	86	59.26	HS	ETBW 8465	97	77.78	HS	ETBW 8517	88	79.01	HS
ETBW 8500	95	55.56	HS	ETBW 8466	87	69.14	HS	ETBW 7101	74	34.57	S
ETBW 8501	32	7.41	R	ETBW 8467	75	43.21	S	ETBW 8518	86	59.26	HS
ETBW	75	43.21	S	ETBW	95	55.5	HS	ETBW	97	77.7	HS

Genotype	Severity		Response	Genotype	Severity		Response	Genotype	Severity		Response
	00-99	%			00-99	%			00-99	%	
8502				8468		6		7872		8	
ETBW 8503	53	18.52	MS	ETBW 7609	97	77.78	HS	ETBW 8519	88	79.01	HS
ETBW 8504	99	100.00	HS	ETBW 7638	87	69.14	HS	ETBW 6937	54	24.69	MS
ETBW 8505	86	59.26	HS	ETBW 7577	98	88.89	HS				

ETBW-Ethiopian Bread Wheat, HR- Highly Resistant, R- Resistant, MR- Moderately resistant, MS-Moderately susceptible, S- Susceptible and HS-Highly susceptible.

Most of the high-yielding bread wheat cultivars grown today are susceptible to Septoria tritici blotch and none of these varieties were fully resistant (Table 2 and 3). All commercial and candidate bread wheat varieties were affected by Septoria tritici blotch at varied intensity levels. Seven (Dodota, Bobicho, Sulla, Nyangumi Kenya, UC110, Kern, and Basha-2) out of 94 bread wheat genotypes sustained the highest possible severity level (99) and percent severity (100%) as that of susceptible checks (Morocco and PBW343). These entries were considered as highly susceptible according to Eyal et al., (1987). In addition, large numbers of bread wheat genotypes (69.2%) were categorized within the highly susceptible and severity scale that range 85-99 (Table 2 and 3). The Septoria infection class (65-84) named as susceptible includes ten commercial and candidate bread wheat varieties (Table 2). Generally, the majority (80.9%) of these genotypes were vulnerable to Septoria tritici blotch population and classified within the range of susceptible to highly susceptible response.

Limited number of genotypes (19.2%) expressed high level of resistance, as indicated by low disease scores. Only one variety' Hoggana' was sustained highly resistant to Septoria tritici blotch populations. In similar way, three (Hidasse, Alidoro and Digelu), two (Tay and K6295-4A) and seven (ETBW6095, Shorima, kakaba, Gassay, Bounty, Bonny and Bolo) bread wheat commercial and candidate varieties were showed resistant, moderately resistant and moderately susceptible response, respectively (Table 2 and 3).

Table 2. The severity and host response bread wheat varieties in 2014.

Genotype	Severity		Response	Genotype	Severity		Response
	(00-99)	(%)			(00-99)	(%)	
ETBW 5879	85	49.4	HS	Ga'ambo	63	22.2	MS
ETBW 6095	52	12.4	MS	Kakaba	65	37.0	MS
WORRAKATTA/PASTOR	87	69.1	HS	Danda'a	83	29.6	S
UTQUE96/3/PYN/BAU//MILLAN	74	34.6	S	Gassay	63	22.2	MS
Hidasse	31	3.7	R	Alidoro	21	2.5	R
Ogolcho	98	88.9	HS	Digelu	52	12.4	R
Hoggana	11	1.2	HR	Tay	42	9.9	MR
Hulluka	84	39.5	S	Sofumer	75	43.2	S
Mekelle-3	75	43.2	S	MadaWolabu	94	44.4	HS
Mekelle-4	98	88.9	HS	Pavon-76	97	77.8	HS
Shorima	53	18.5	MS	Geferson	97	77.8	HS
Mekelle-1	99	100	HS	King Bird	84	39.5	S
Mekelle-2	99	100	HS				

Table 3. The severity and host response of commercial and candidate bread wheat varieties in 2014 used in trap nursery.

Genotype	Severity		Response	Genotype	Severity		Response
	(00-99)	(%)			(00-99)	(%)	
Bounty	64	29.6	MS	Megal	84	39.5	S
Bonny	64	29.6	MS	Morocco	99	100	HS
Frontach	86	59.3	HS	PBW343	99	100	S
Kenya Kudu	89	88.9	HS	Tusie	75	43.2	S
Enkoy	86	59.3	HS	Katar	86	59.3	HS
K6290 Bulk	74	34.6	S	Shinna	87	69.1	HS
K6295-4A	42	9.9	MR	Tura	88	79	HS
ET13A2	84	39.5	S	Hawi	87	69.1	HS
Dashen	88	79	HS	Simba	89	88.9	HS
Mitikie	32	7.4	R	Watera	88	79	HS
Galema	88	79	HS	Dodota	99	100	HS
Kubsa	85	49.4	HS	Dure	89	88.9	HS
Abola	86	59.3	HS	KBG-01	85	49.4	HS
Ejerssa	86	59.3	HS	Sirbo	96	66.7	HS
Clear white	96	66.7	HS	Bobicho	99	100	HS
Lassik (+Yr5)	95	55.6	HS	Tossa	86	59.3	HS
UC110	99	100	HS	Meraro	85	49.4	HS
Kern	99	100	HS	Senkegna	86	59.4	HS
UC1107	97	77.8	HS	Sulla	99	100	HS
Roelfs F2007	97	77.8	HS	Millennium	89	88.9	HS
Dinknesh	64	29.6	MS	Laketch	89	88.89	HS
Menze	96	66.7	HS	Kenya Leopard	85	49.38	HS
HAR 719	98	88.9	HS	K/Nyangumi	99	100	HS
Lassik (-Yr5)	97	77.8	HS	Africa Mayo	64	29.63	MS
Patwin	95	55.6	HS	Trophy	85	49.38	HS
UC1600-Kern	94	44.4	HS	Kulkulu	87	69.14	HS
ETBW5800	88	79	HS	Bolo	64	29.63	MS
ETBW5890	95	55.6	HS	Galil	88	79.01	HS
ETBW6093	85	49.4	HS	Tsehay	96	66.7	HS
ETBW6094	95	55.6	HS	Arendeto	83	29.6	S
ETBW6098	97	77.8	HS	HAR 727	97	77.8	HS
HAR 1407	53	18.5	MS	HAR 723	97	77.8	HS
HAR 1331	89	88.9	HS	HAR 934	85	49.4	HS
Basha-2	99	100	HS	HAR 1018	86	49.4	HS
HAR 820	87	69.14	HS				

HR- Highly Resistant, R- Resistant, MR- Moderately resistant, MS-Moderately Susceptible, S- Susceptible and HS-Highly Susceptible

The range among cultivar severity was somewhat greater than in the bread wheat than durum because severity values were not truncated by the maximum possible value (99). Seven out of 20 durum wheat varieties were ranged from susceptible to highly susceptible (65-94) of infection response (Table 4). On the other hand, the majority (65%) of the durum varieties were sustained infection response that ranged from resistant to moderately susceptible. Three varieties; Mukiye, Mangudo and Yerer were sustained minimum severity score and infection response of resistant to the disease. This better tolerance of durum wheat varieties might be associated with the fact that most of the durum wheat cultivars were developed from local landraces, which have co-evolved with indigenous pathogen populations (Belayneh et al., 2009). In contrast, bread wheat cultivars were introduced into the country via different ways including genotypes developed by international breeding programs elsewhere from similar genetic background. In many countries (Eyal, 1981; Scharen and Eyal, 1983), durum wheat and triticales have a higher frequency of resistance to Septoria tritici blotch than spring bread wheat varieties. In contrast, in Tunisia several bread wheat lines and cultivars were highly resistant to Septoria tritici blotch whereas very few durum wheat cultivars showed good resistance (Djerbi et al., 1976). This condition might result from the fact that durum wheat are widely grown in Tunisia, thus producing directed selection pressure on the pathogen to adapt to durum wheat rather than bread wheat, which are grown on a much smaller scale (Eyal et al., 1987).

Table 4. The severity and host response of durum wheat commercial varieties in 2014.

Genotype	Severity		Response	Genotype	Severity		Response
	(00-99)	(%)			(00-99)	(%)	
Malefia	85	49.38	HS	Mangudo	22	4.94	R
Mossobo	63	22.22	MS	Mukiye	23	7.41	R
Toltu	74	34.57	S	Hitossa	42	9.88	MR
Obssa	85	49.38	HS	Werer	42	9.88	MR
Lellisso	83	29.63	S	Denbi	53	18.52	MS
Tate	42	9.88	MR	Megenagna	64	29.63	MS
Bakalcha	53	18.52	MS	Mettaya	42	9.88	MR
Oda	42	9.88	MR	Felakit	86	59.26	HS
Kokate	42	9.88	MR	Local Red	94	44.44	HS
Illani	85	49.38	HS	Yerer	33	11.11	R

HR- Highly Resistant, R- Resistant, MR- Moderately resistant, MS-Moderately Susceptible, S- Susceptible and HS-Highly Susceptible.

Generally, previous report indicated that the emphases of disease management research was on the identification of host plant resistance and /or tolerance to major diseases from different nurseries for use in the breeding programs and to some extent on the incorporation of disease resistant traits in to promising cultivars. As other disease, however, satisfactory result(s) on resistance was not found to the diseases in Ethiopia (Ayele et al., 2008). The present finding is consistent with previous findings in that, despite many host resistance studies of bread wheat to Septoria tritici blotch, no variety or line has been identified with a high level of resistance (Eshetu, 1985; Yeshi et al., 1990). The higher susceptibility of wheat genotypes could be mainly due to prevailing climactic conditions suitable for its development (frequent rains and moderate temperature) (Gilchrist and Dubin, 2002) and having wider virulence spectrum of the pathogen population. According to McDonald et al., (1999) and Kema et al., (1996) the population of Septoria tritici blotch is highly diverse genetically and the fungus may reproduce sexually several times during the wheat-growing season. This increases the risk of adaptation of the pathogen to resistance genes deployed in the host population.

Conclusion

This study showed that none of the genotypes were resistance to Septoria tritici blotch and the majority was susceptible to highly susceptible. This suggests that 'gene pyramiding' would be efficient when breeding for resistance to the disease and narrowing the potential and actual yields gabs.

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