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Evaluation of Some Bread Wheat (*Triticum aestivum* L.) Varieties Reaction to Septoria Tritici Blotch Disease

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Abstract: Septoria tritici blotch (STB), caused by the *Zymoseptoria tritici* is an important wheat (*Triticum aestivum* L.) disease in the Türkiye and in many countries in the world. In this study, a total of 92 bread wheat varieties were evaluated for STB in the adult plant stage under natural infection conditions. The field trial was performed at the experimental station at the campus of Akdeniz University, Antalya, Türkiye for two consecutive years with the two replications. Disease evaluations were performed using the double-digit scale (00-99). Based on the disease evaluations, the disease severity ranged from 15 to 80, and 21 to 82 in the growing seasons 2022 and 2023, respectively. In infection types, four disease reactions were determined namely resistant, moderately resistant, moderately susceptible, and susceptible. Overall, while 32.61% and 36.96% of the varieties were resistant and moderately resistant to STB, 17.39% and 13.04% of them showed moderately susceptible and susceptible reactions, respectively. In conclusion, these varieties can be used in resistance breeding programs to STB disease. In further studies, the resistant/susceptible reactions of bread wheat varieties to STB should be identified to carry which resistance gene/genes or not.

Keywords: Bread wheat, *Zymoseptoria tritici*, disease severity, infection type, natural infection

1. Introduction

Bread wheat (*Triticum aestivum* L., 2n= 6x= 42, AABBDD), is a widely cultivated cereal crop in the world and it provides 20% of the calories consumed by humans (Singh and Upadhyaya, 2015). The current annual wheat production is approximately 730 million tons in the world and it is expected to exceed 900 million tons per year by 2050 (Peters Haugrud et al., 2022). It is necessary to increase in wheat yield to meet this increasing demand. However, wheat production is constrained by biotic and abiotic stress factors. Diseases caused by fungal pathogens are among the most important biotic factors limiting wheat production. Septoria tritici blotch (STB) caused by the fungal pathogen *Zymoseptoria tritici* has been known as the most challenging foliar disease in wheat within the humid climatic region that includes Türkiye and European countries, causing serious yield losses (Fones and Gurr, 2015).

There is usually an occurrence of the disease between March and July and the pathogen overwinters either on the plants (seeds, stubble, debris and volunteer plants) or in the form of survival structures (ascospores, pycnidiospores, mycelium) (Eyal et al., 1987). The fungus has been demonstrated to exhibit a hemibiotrophic (Fones and Gurr, 2015), characterized by two main stages. Firstly, an initial symptomless period phase referred to as biotrophic is to 10 to 12 days, during which the hyphae penetrate the leaves through stomata and colonize leaf tissues occupying the substomatal while remaining confined to the intercellular space (Kema et al., 1996), and then a subsequent necrotrophic phase, in which the infected tissue begins necrosis, causing the collapse of host mesophyll cells (Duncan and Howard, 2000). The pathogen can produce many asexual infection cycles in one growing season under favorable weather conditions and it rapidly evolves and easily overcome resistance genes due to its mixed

reproduction phase, large population sizes, and long-distance spread (Ben M'Barek et al., 2023).

Under severe epidemics, high yield losses up to 50% were observed in susceptible wheat varieties (Eyal et al., 1987). The most widely used methods of controlling STB are fungicides, seed treatments, and foliar spray applications. However, resistant varieties or genotypes are the more efficient, economical, and environmentally friendly approach for managing STB (Mergoum et al., 2007). To date, 22 resistance genes named Stb have been identified and characterized in wheat germplasm (Yang et al., 2018). Most of them are genotype specific and effective to only a few pathogen isolates (Gupta et al., 2023). In addition, the resistance genes can also be effective in seedling or adult plant stages independently.

Concerning current disease, extensive research has been conducted by various researchers worldwide, focusing on key aspects such as the significance of the pathogen (Das et al., 2020; Tadesse and Yewste, 2023), pathogenic variation (da Costa et al., 2022), disease reactions to varieties (Mergoum et al., 2007; Omrani et al., 2023), resistance genes (Yang et al., 2018; Tidd et al., 2023), and fungicide resistance (Taylor and Cunniffe, 2023). In Türkiye, the disease was first reported by İren (1962). Subsequently, studies on STB disease have been carried out in different regions of Türkiye (Unal et al., 2017; Eğerci et al., 2020, 2021; Zemran, 2020; Kılınç et al., 2021). In line with these studies above, it is observed that the effectiveness of STB has increased in wheat production areas in recent years. Therefore, it is necessary to test the existing varieties both against the current disease population and the identified races. The objective of this study was to evaluate the reactions of some bread wheat (*T. aestivum* L.) varieties to STB disease at the adult plant stage under natural infection conditions.

2. Materials and Methods

2.1. Plant material

A total of 92 bread wheat (*T. aestivum* L.) varieties registered in Türkiye between 1963 and 2014 were used as genetic material in this study. In addition, the bread wheat variety "Morocco" known to be susceptible to STB disease, was used as the control. Information about these materials is given in Table 1.

Table 1. Variety name and release year of the bread wheat varieties used in this study

No	Variety	Release year	No	Variety	Release year
1	Ankara 093/44	1963	32	Mızrak	1998
2	Köse 220/39	1963	33	Türkmen	1998
3	Sivas 111/33	1963	34	Uzunyayla	1998
4	Sürak M. 1593/51	1963	35	Yıldız-98	1998
5	P 8-8	1963	36	Pehlivan	1998
6	Yektay 406	1968	37	Karacadağ-98	1998
7	Bezostaja-1	1968	38	Gönen-98	1998
8	Bolal-2973	1970	39	Ziyabey-98	1998
9	Kıraç-66	1970	40	Yakar-99	1999
10	Tosun-21	1975	41	Karahan-99	1999
11	Porsuk-2800	1976	42	Ceyhan-99	1999
12	Cumhuriyet-75	1976	43	Flamura-85	1999
13	Gerek-79	1979	44	Aksel-2000	2000
14	Kırkpınar-79	1979	45	Bayraktar-2000	2000
15	Atay-85	1985	46	Demir-2000	2000
16	Ata-81	1985	47	Tahirova-2000	2000
17	İzmir-85	1985	48	İzgi-2001	2001
18	Kate A-1	1988	49	Sönmez-2001	2001
19	Kaklıç-88	1988	50	Atilla-12	2001
20	Gün-91	1991	51	Alparslan	2001
21	Kutluk-94	1994	52	Pandas (Panda)	2001
22	Dağdaş-94	1994	53	Sagittario	2001
23	Kırgız-95	1995	54	Zencirci-2002	2002
24	Sultan-95	1995	55	Soyer-02	2002
25	Kaşif Bey-95	1995	56	Eser	2003
26	İkizce-96	1996	57	Canik-2003	2003
27	Kınacı-97	1997	58	Özdemirbey-97	2003
28	Palandöken-97	1997	59	Seval	2004
29	Bandırma-97	1997	60	Tosunbey	2004
30	Karacabey-97	1997	61	Ahmetağa	2004
31	Pamukova-97	1997	62	Krasunia odes'ka	2008

Table 1. (Continued)

No	Variety	Release year	No	Variety	Release year
63	Kenanbey	2009	78	Aglika	2012
64	Aldane	2009	79	Tsarevets	2012
65	Selimiye	2009	80	Dinç	2013
66	Yunak	2009	81	Gökkan	2013
67	Hakan	2009	82	Segor	2013
68	Lütfibey	2010	83	Adelaide	2013
69	ES-26	2010	84	Artico	2013
70	Esperia	2011	85	Avorio	2013
71	Cömert	2011	86	Tekin	2014
72	Turan	2011	87	Metin	2014
73	Martar	2011	88	Nevzatbey	2014
74	Vittorio	2011	89	Yakamoz	2014
75	Altındane	2012	90	Bora	2014
76	Quality	2012	91	Genesi	2014
77	Rumeli	2012	92	Galateya	2014

2.2. Isolation and purification of pathogen

Leaf samples showing blotch symptoms caused by *Z. tritici* were collected from the experimental station of Akdeniz University, Antalya, Türkiye. The pathogen was isolated from the infected leaf tissue using the method reported by Eyal et al. (1987). Briefly, in this method, pieces of the infected leaves were placed on the Petri plates containing moist filter paper and the plates were incubated at room temperature for one day. After the incubation period, the spores discharged from the pycnidia were extracted using a sterile needle and subsequently transferred to potato dextrose agar (PDA).

2.3. Field experiment and observations

In this study, 92 bread wheat varieties were evaluated for STB disease in the adult plant stage. From this context, the field experiments were conducted in Akdeniz University, Antalya, Türkiye, in the 2021-2022 and 2022-2023 growing seasons. Each genotype was planted in two randomized replications, with 1 meter lines and a 30 cm space. In addition, conventional management and fertilization were applied during the growing period of wheat. Disease evaluations were performed using the method (Saari and Prescott, 1975) based on a double-digit scale (00-99) which was modified by Eyal et al. (1987). In this scale, the first digit represented progression of the disease from lower to upper foliage, while the subsequent digit indicated the severity of the disease. Infection type was determined using a scale described by Dalvand et al. (2014). According to this scale, the bread wheat varieties were clustered as immune (I, 00), highly resistant (HR, 11-14), resistant (R, 15-34), moderately resistant (MR, 35-44), moderately susceptible (MS, 45-64), susceptible (S, 65-84), and very susceptible (VS, 85-99) respectively.

2.4. Data analysis

All obtained data were first recorded in Microsoft Excel. Basic statistical parameters and correlation analysis were performed in Minitab software (Minitab Inc., USA).

3. Results and Discussions

The assessment of disease severity in plant-pathogen systems can be carried out through a single evaluation or multiple assessments at intervals from the onset of the disease until the conclusion of the epidemic. In the evaluation of Septoria disease reaction, a double-digit scale (00-99) is commonly used by many researchers (Azene et al., 2020). Here, it was assessed disease severity under field conditions to investigate bread wheat varieties for their resistance to STB in Antalya province. The statistical analysis showed that high correlations among the disease reactions of all bread wheat varieties in two years were determined (Figure 1). This finding is in agreement with the study conducted by Karisto et al. (2018) who was detected in a high correlation in STB infection. Similarly, the same results were reported by Odilbekov et al. (2018).

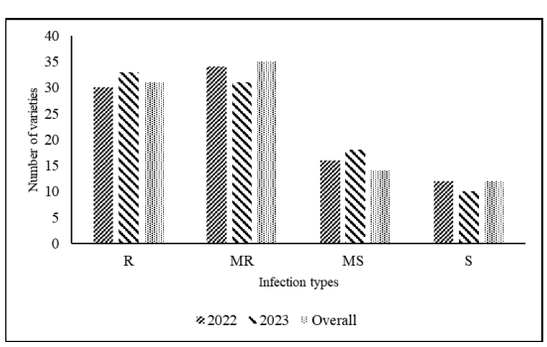

Figure 1. Number of varieties representing different reactions of STB

The bread wheat varieties were evaluated for their resistance to the STB disease at the adult plant stage. Among the varieties, disease severity changed from 15 to 80, and 21 to 82 in the growing seasons 2021-2022 and 2022-2023, respectively. Moreover, kurtosis and skewness values also confirmed normal distribution for disease severity among the varieties in both years (Table 2). Based on the highest disease reaction of the two replications, the susceptible check "Morocco" had a high disease severity (ds>80) (Table 3). Based on the infection types, four reactions were determined including resistant, moderately resistant, moderately susceptible and susceptible reaction. On the other hand, immune, highly resistant and very susceptible reaction were not found. Similar results were reported by Omrani et al. (2023) who stated that 53 elite wheat lines were tested against the STB disease at adult plant stage in natural infection conditions in the 2020 and 2021 growing seasons, and it was determined that the tested materials showed moderately resistant, moderately susceptible and susceptible reaction. Also, in their studies, high virulence was observed in the Stb3, Stb4, Stb7, Stb8 and Stb9 resistance genes, where avirulence was found in Stb11 and Stb18 in both years. In addition, according to Muche (2022), it was stated that a considerable variation in response to STB among both commercially available bread wheat varieties and advanced lines, ranging from resistant to susceptible. This observation aligns with findings from a study by Teklay et al. (2015), which reported diverse responses among bread wheat varieties to STB disease.

Table 2. Basic statistical parameters of reactions of all varieties in both years and overall

Season	N	Mean	Minimum	Maximum	CV (%)	SD	Kurtosis	Skewness
2021-2022	92	41.36	15.00	80.00	37.44	15.48	0.80	0.16
2022-2023	92	41.88	21.00	82.00	35.47	14.86	1.05	0.47
Overall	92	59.75	18.00	81.00	36.16	15.05	0.94	0.34

CV: Coefficient of variation, SD: Standard deviation

Table 3. Disease severity (DS) and infection types (ITs) of the bread wheat varieties to STB disease

No	Variety name	2022		2023		Overall	
		DS	IT	DS	IT	DS	IT
1	Ankara 093/44	44	MR	48	MS	46	MS
2	Köse 220/39	35	MR	38	MR	36.5	MR
3	Sivas 111/33	24	R	22	R	23	R
4	Sürak	32	R	28	R	30	R
5	P 8-8	32	R	30	R	31	R
6	Yektay-406	30	R	33	R	31.5	R
7	Bezostaja-1	48	MS	51	MS	49.5	MS
8	Bolal-2973	16	R	22	R	19	R
9	Kıraç-66	22	R	26	R	24	R
10	Tosun-21	80	S	82	S	81	S
11	Porsuk-2800	32	R	36	MR	34	R
12	Cumhuriyet-75	40	MR	38	MR	39	MR
13	Gerek-79	18	R	23	R	20.5	R
14	Kırkpınar-79	75	S	74	S	74.5	S
15	Atay-85	28	R	25	R	26.5	R
16	Ata-81	32	R	34	R	33	R
17	İzmir-85	15	R	21	R	18	R
18	Kate A-1	28	R	34	R	31	R
19	Kaklıç-88	68	S	62	MS	65	S
20	Gün-91	40	MR	36	MR	38	MR
21	Kutluk 94	26	R	28	R	27	R
22	Dağdaş-94	38	MR	34	R	36	MR
23	Kırgız-95	45	MS	42	MR	43.5	MR
24	Sultan-95	36	MR	38	MR	37	MR
25	Kaşif Bey-95	40	MR	44	MR	42	MR
26	İkizce-96	42	MR	38	MR	40	MR
27	Kınacı-97	42	MR	43	MR	42.5	MR
28	Palandöken-97	55	MS	52	MS	53.5	MS
29	Bandırma-97	34	R	37	MR	35.5	MR
30	Karacabey-97	74	S	78	S	76	S
31	Pamukova-97	80	S	78	S	79	S
32	Mızrak	70	S	72	S	71	S

Table 3. (Continued)

No	Variety name	2022		2023		Overall	
		DS	IT	DS	IT	DS	IT
33	Türkmen	40	MR	38	MR	39	MR
34	Uzunyayla	42	MR	45	MS	43.5	MR
35	Yıldız-98	36	MR	32	R	34	R
36	Pehlivan	26	R	32	R	29	R
37	Karacadağ-98	48	MS	44	MR	46	MS
38	Gönen-98	38	MR	36	MR	37	MR
39	Ziyabey-98	34	R	38	MR	36	MR
40	Yakar-99	68	S	62	MS	65	S
41	Karahan-99	38	MR	35	MR	36.5	MR
42	Ceyhan-99	42	MR	46	MS	44	MR
43	Flamura-85	56	MS	52	MS	54	MS
44	Aksel-2000	75	S	78	S	76.5	S
45	Bayraktar-2000	40	MR	42	MR	41	MR
46	Demir-2000	36	MR	32	R	34	R
47	Tahirova-2000	38	MR	36	MR	37	MR
48	İzgi-2001	48	MS	54	MS	51	MS
49	Sönmez-2001	20	R	25	R	22.5	R
50	Atilla-12	38	MR	32	R	35	MR
51	Alparslan	26	R	24	R	25	R
52	Pandas (Panda)	70	S	72	S	71	S
53	Sagittario	55	MS	52	MS	53.5	MS
54	Zencirci-2002	70	S	68	S	69	S
55	Soyer-02	24	R	26	R	25	R
56	Eser	32	R	28	R	30	R
57	Canik-2003	20	R	24	R	22	R
58	Özdemirbey-97	38	MR	36	MR	37	MR
59	Seval	26	R	32	R	29	R
60	Tosunbey	40	MR	44	MR	42	MR
61	Ahmetağa	42	MR	48	MS	45	MS
62	Krasunia odes'ka	54	MS	48	MS	51	MS
63	Kenanbey	50	MS	52	MS	51	MS
64	Aldane	34	R	32	R	33	R
65	Selimiye	18	R	24	R	21	R
66	Yunak	36	MR	34	R	35	MR
67	Hakan	24	R	28	R	26	R
68	Lütfibey	30	R	36	MR	33	R
69	ES-26	38	MR	34	R	36	MR
70	Esperia	73	S	75	S	74	S
71	Cömert	64	MS	62	MS	63	MS
72	Turan	40	MR	36	MR	38	MR
73	Martar	48	MS	46	MS	47	MS
74	Vittorio	54	MS	58	MS	56	MS
75	Altındane	46	MS	42	MR	44	MR
76	Quality	65	S	68	S	66.5	S
77	Rumeli	38	MR	42	MR	40	MR
78	Aglika	36	MR	32	R	34	R
79	Tsarevets	45	MS	43	MR	44	MR
80	Dinç	42	MR	36	MR	39	MR
81	Gökkan	40	MR	48	MS	44	MR
82	Segor	31	R	28	R	29.5	R
83	Adelaide	42	MR	44	MR	43	MR
84	Artico	37	MR	35	MR	36	MR
85	Avorio	35	MR	42	MR	38.5	MR
86	Tekin	38	MR	36	MR	37	MR
87	Metin	38	MR	42	MR	40	MR
88	Nevzatbey	26	R	32	R	29	R
89	Yakamoz	58	MS	56	MS	57	MS
90	Bora	32	R	34	R	33	R
91	Genesi	20	R	26	R	23	R
92	Galateya	46	MS	42	MR	44	MR
93	Morocco	83	S	84	S	83.5	S

In the 2022 season, the lowest disease severity was detected in İzmir-85 variety (ds: 15), while the highest severity was detected in Tosun 21 and Pamukova-97 varieties (ds: 80). Regarding infection types, Sivas 111/33, Sürak, P8-8, Yektay 406, Bolal 2973, Kıraç 66, Porsuk-2800, Gerek-79, Atay-85, Ata-81, Izmir-85, Kate A-1, Kutluk-94, Bandırma-97, Pehlivan, Ziyabey-98, Sönmez-2001, Alparslan, Soyer-02, Eser, Canik-2003, Seval, Aldane, Selimiye, Hakan, Lütfibey, Segor, Nevzatbey, Bora, and Genesi varieties showed resistant reaction (ds: from 15 to 34). On the other hand, 12 varieties, namely, Tosun-21, Kırkpınar-79, Kaklıç-88, Karacabey-97, Pamukova-97, Mızrak, Yakar-99, Aksel-2000, Pandas, Zencirci-2002, Esperia, and Quality showed susceptible reaction (ds: from 65 to 80). In this season, 33.7% of all varieties showed a moderately resistant reaction to STB (Figure 2). This result is in agreement with Azene et al. (2020) finding which reported that 100 bread wheat varieties were evaluated at adult plant stage in the 2019 and 2020 growing seasons and 60 were found to be moderately resistant and 40 were to moderately susceptible reactions.

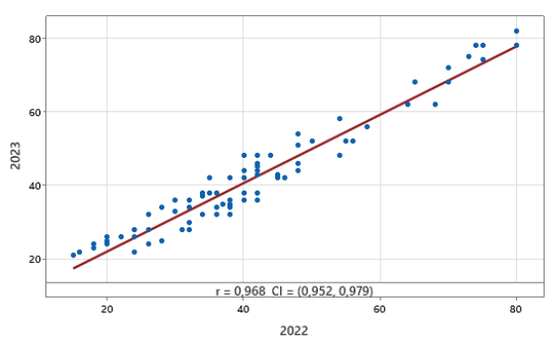

Figure 2. Correlations between disease severity of all bread wheat varieties in two growing seasons

In the 2023 season (Table 3), the lowest disease severity was detected in the İzmir-85 variety (ds: 21), whereas the highest disease severity was observed in the Tosun-21 variety (ds: 82). Considering infection types; Tosun-21, Kırkpınar-79, Karacabey-97, Pamukova-97, Mızrak, Aksel-2000, Pandas, Zencirci-2002, Esperia, and Quality varieties showed susceptible reaction (ds: from 21 to 82), while Sivas 111/33, Sürak, P8-8, Yektay 406, Bolal 2973, Kıraç 66, Gerek-79, Atay-85, Ata-81, Izmir-85, Kate A-1, Kutluk-94, Dağdaş-94, Yıldız-98, Pehlivan, Demir-2000, Sönmez-2001, Atilla-12, Alparslan, Soyer-02, Eser, Canik-2003, Seval, Aldane, Selimiye, Yunak, Hakan, ES-26, Aglika, Segor, Nevzatbey, Bora, and Genesi varieties showed resistant reaction (ds: from 68 to 82). In the same year, 35.7% of all varieties showed resistant reaction to this disease. The different disease reactions among the bread wheat varieties in growing seasons could be explained by the weather conditions and the dynamics of STB populations.

Overall, while Tosun-21 had a high disease severity (ds:81) the lowest was İzmir-85 (ds: 18) (Table 3). It was also determined that 33.7% of the tested varieties were resistant and 13% of which showed a susceptible reaction (Figure 2). The resistance varieties identified in this study may contain various resistance genes, and the usage of these genes in gene pyramiding could be beneficial varieties with broad and durable resistance to STB disease may prove valuable in breeding initiatives aimed at enhancing resistance to this disease in wheat

4. Conclusions

In this study, it was found that some bread wheat varieties have shown different levels of disease reactions (R, MR, MS, and S) to STB disease under natural infection conditions based on the phenotypic data. Increasing our understanding of the epidemiology of *Zymoseptoria tritici* will provide tools to develop more effective management for this pathogen. Further screening of more diverse wheat germplasm, especially landraces and wild relatives and breeding lines used in germplasm collection, could identify sources of resistance to this pathogen for wheat breeding programs. Studies evaluating the impact of the development of this disease combined with the molecular data could also help define results that minimize the impact of STB in wheat.

Ethical Statement

The author declares that ethical approval is not required for this research.

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Declaration of Conflicts of Interest

No conflict of interest has been declared by the author.

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