Türk Tarım ve Doğa Bilimleri Dergisi 11(2): 574–582, 2024
https://doi.org/10.30910/turkjans.1378612

TÜRK TARIM ve DOĞA BİLİMLERİ DERGİSİ

TTDB

TURKISH JOURNAL of AGRICULTURAL and NATURAL SCIENCES

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Araştırma Makalesi

Reactions of Tetraploid Wheat Species *to Septoria tritici Blotch*

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Geliş Tarihi: 24.10.2023 Düzeltme Geliş Tarihi: 17.04.2024 Kabul Tarihi: 20.04.2024

ABSTRACT

Septoria tritici blotch (STB), caused by the ascomycete fungal pathogen *Zymoseptoria tritici* is one of the destructive diseases of wheat global scale and it causes severe yield losses in suitable conditions. The aim of this study was to evaluate on the 84 tetraploid wheat species to STB disease during 2020-2021 and 2021-2022 growing seasons. The experiment was conducted randomized block design with two replications at campus of Akdeniz University. Based on the disease observations, it was determined that 39 (46.4%) of the tested genotypes showed susceptible and highly susceptible reaction in 2021, while 18 (21.4%) showed resistant and moderately resistant reaction. In addition, 44 (52.4%) of the genotypes showed susceptible and highly susceptible reaction, and 15 (17.8%) showed resistant and moderately resistant reaction in 2022. Overall, while all Polish wheat species showed highly susceptible reaction, only one emmer wheat species (*T. dicoccum* var. *haussknechtianum*) showed immune reaction in two seasons. Besides, durum wheat varieties namely Akbaşak 073/144, Çakmak 79, Altıntaş 95, Yelken 2000, Fırat-93 and Fuatbey 2000 showed resistant reaction and also no highly susceptible reaction was detected in durum wheat varieties. To sum up, identified resistant durum and emmer wheat species/varieties can be used in breeding programs to be conducted for resistance to STB disease.

Key words: Tetraploid wheat species, *Septoria tritici blotch*, disease severity, infection type, resistance

Tetraploid Buğday Türlerinin *Septoria tritici Blotch* Hastalığına Karşı Reaksiyonları

ÖZ

Ascomycetes fungal patojen *Zymoseptoria tritici*'nin neden olduğu *Septoria tritici blotch* (STB) buğdayın küresel düzeyde yıkıcı hastalıklarından biridir ve uygun koşullarda önemli verim ve kalite kayıplarına neden olur. Bu çalışma, 84 tetraploit buğday türünün STB hastalığına karşı dayanıklılığını belirlemek amacıyla 2020-2021 ve 2021-2022 yetiştirme sezonlarında gerçekleştirilmiştir. Çalışmada kullanılan çeşitler tesadüf parselleri deneme desenine göre iki tekerrür olacak şekilde Akdeniz Üniversitesi yerleşkesinde yetiştirilmiştir. Hastalık gözlemlerine göre; 2021'de, test edilen genotiplerin 39 (%46.4) 'nun STB hastalığına karşı hassas ve çok hassas reaksiyonlar gösterdiği belirlenmiştir. Yine aynı yıl, genotiplerin 18 (%21.4)' i dayanıklı ve orta derecede dayanıklı olduğu saptanmıştır. 2022'de, genotiplerin 44 (%52.4)'ü STB hastalığına karşı hassas ve çok hassas reaksiyonlar gösterirken, 15 (%17.8) 'i dayanıklı ve orta derecede dayanıklı reaksiyon göstermiştir. Özellikle tüm Polonya buğday türlerinin STB hastalığına karşı çok hassas reaksiyonlar gösterdiği belirlenmiştir. Öte yandan, bir gernik buğday türü, *Triticum dicoccum* var. *haussknechtianum*, her iki sezonda da dayanıklı olduğu tespit edilmiştir. Ayrıca, Akbaşak 073/144, Çakmak 79, Altıntaş 95, Yelken 2000, Fırat-93 ve Fuatbey 2000 gibi makarnalık buğday çeşitleri STB hastalığına karşı dayanıklı olduğu ve makarnalık buğday çeşitlerinde çok hassas reaksiyon saptanmamıştır. Sonuç olarak, belirlenen dayanıklı durum ve emmer buğday türleri/çeşitleri, STB hastalığına karşı dayanıklılık ıslah programlarında kullanılma potansiyeline sahiptir.

Anahtar kelimeler: Tetraploid buğday türleri, septoria yaprak lekesi, hastalık şiddeti, enfeksiyon tipi, dayanıklılık

INTRODUCTION

Wheat (*Triticum* spp.) is major staple crop and is intensively grown globally. According to the FAO (2021) statistical data, it has been cultivated 220.7 million hectares area with a production of 770 million tonnes. There are two types of wheat commonly used in the world. These are *Triticum aestivum* L. (2n=42=AABBDD) and tetraploid durum wheat, *Triticum durum* Desf. (2n=28=AABB)) (Shewry and Hey, 2015). In addition to these species, there are hulled wheats with different genome structures, such as diploid einkorn wheat, tetraploid emmer wheat and hexaploid spelt wheat. These are considered transitional forms between modern and wild wheat species (Akar and Eser, 2016). Among these hulled wheat species, while spelt wheat is not cultivated in Türkiye, there has been an increased interest in einkorn wheat and emmer wheat in recent years compared to durum and bread wheat varieties (Coşkun et al., 2019). The history of the wheat, it is accepted that the source of the B genome is *Aegilops speltoides* Tausch ($2n = 2x = 14$, SS). and the source of the A genome in modern tetraploid species is *T. urartu* (Levy and Feldman, 2004; Rudnoy et al., 2004). The wild emmer wheat (*T. dicoccoides*) originated through natural hybridization of the A and B genome sources (Shewry, 2009). The popularity of tetraploid wheat species namely durum wheat, emmer, and Polish wheat, has significantly increased. Among of them, durum wheat is widely cultivated and is the most economically important species of tetraploid wheat (Sissons, 2008) due to the using of the pasta and semolina production. A total of 19.750 milllion tons of wheat were produced and 3.750 million tons of its was the durum wheat in Türkiye in 2022 growing season according to the TUIK statistical data (TUIK, 2022).

Emmer wheat (*T. dicoccon*) is an important cereal that is among the first cultivated plants and has been a staple crop for millennia. It was cultivated in ancient times different regions of the world. Recently, it is a minor crop and grown mostly in rural areas where agricultural production is not economically grown. On the other hand, emmer wheat has a valuable resistance source for major fungal pathogens such as rusts, powdery mildew, fusarium head blight, septoria tritici blotch (STB) and tan spot (Singh et al., 2005; Zaharieva et al., 2010; Kashyap et al., 2022). In addition to this, nutrition values of emmer wheat is high in dietary fibre, biactive compounds and some mineral and vitamins (Kashyap et al., 2022).

Triticum polonicum known as Polish wheat is a species of wheat that is native to Poland and is cultivated some other regions of Europe. This species is considered as wild of wheat and it has a valuable genetic importance to in breeding of resistance and quality traits. In addition, Wiwart et al. (2013) indicated that this wheat species can be used in resistance breeding programs to Fusarium head blight.

Fungal diseases, mainly rusts, leaf blotch, powdery mildew and fusarium head blight negatively affect wheat yield and quality. Among these diseases, the ascomycetes fungus *Zymoseptoria tritici* formerly known as *Mycosphaerella graminicola,* anamorph *Septoria tritici* (Quaedvlieg et al., 2011), is a fungal pathogen that causes STB, a destructive disease primarily affecting wheat and yield losses cause up to 50% in severe infection conditions (Eyal, 1999). The pathogen is a hemibiotrophic that parasitizes living tissues and can also maintain its vitality in dead host tissues. There is a possibility of new virulent and fungicide-resistant pathotypes emerging due to commonly its reproduction sexually (Linde et al., 2002). Although there are many control methods available for management to STB , the most effective, environmentally safely, reliable and sustainable approach is genetic/host resistance (Fones and Gurr, 2015). Generally, majority of the durum wheat varieties were moderately to highly susceptible based on low genetic variation in the elite gene pool and this situation impede on resistance breeding in durum wheat (Clarke et al., 2010; Miedaner and Longin 2014). To overcome this, introgression of resistance gene(s) into durum wheat are needed which provides their relatives of durum wheat included in genetic pool. Several studies have been conducted on the different fungal diseases in tetraploid wheat in the world however tetraploid wheat species in Türkiye have not been evaluated for resistance to STB . The aim of this study was therefore to evaluate a set of 84 tetraploid wheat species consisting of 53 registered durum wheat varieties in Türkiye, 12 emmer wheat and 19 Polish wheat species, for reaction to STB under natural infections conditions at adult plant stages 2020-2021 and 2021-2022 seasons. The relationship between STB severity and their reactions were also evaluated in each year and overall. The findings obtained from current study will provide on the identification of resistant tetraploid species that can be used in breeding programs to STB in Türkiye.

MATERIALS AND METHODS

In this study, a total of 84 tetraploid wheat species, consisting of 53 durum wheat, 12 emmer wheat and 19 polish wheat were used as plant materials. Information about of them were given in Table 1. These genotypes were provided by the Department of Field Crops of Akdeniz University, Antalya, Türkiye. In addition, susceptible bread wheat material “Morocco” was used as susceptible control. The 84 tetraploid wheat species were grown in a randomized complete block design with two replicates in the experimental site at the location of Akdeniz University in Antalya, Türkiye during 2020-2021 and 2021-2022 growing seasons to evaluate on natural infection conditions for the STB. The seeds were sown in rows that measured 100 cm in length, with a 35 cm gap between rows. Susceptible control "Morocco" was sown after 10 rows. The experiments were sprinkler-irrigated to ensure a humid setting conducive to the development of pathogen. In addition, Cultural practices were performed manually.

Table 1. Information about the tetraploid wheat species used in this study.

Durum wheat genotypes					
No	**Variety name**	**Registration year**	**No**	**Variety name**	**Registration year**
1	Akbaşak 073/144	1964	28	Fırat-93	2002
2	Kunduru 414/44	1963	29	Artuklu	2008
3	Berkmen 469	1967	30	Eyyubi	2008
4	Çakmak 79	1979	31	Şahinbey	2008
5	Kızıltan 91	1991	32	Zühre	2010
6	Altın 40/98	1998	33	Güney Yıldızı	2010
7	Yılmaz 98	1998	34	Gediz-75	1976
8	Ankara 98	1998	35	Ege 88	1988
9	Çeşit-1252	2000	36	Salihli 92	1992
10	Mirzabey 2000	2000	37	Şölen 2002	2002
11	Eminbey	2009	38	Tüten 2002	2002
12	İmren	2009	39	GAP	2004
13	Kunduru 1149	1967	40	Turabi	2004
14	Altıntaş 95	1995	41	Sham-1	1991
15	Kümbet 2000	2000	42	Amanos-97	1997
16	Yelken 2000	2000	43	Fuatbey 2000	2000
17	Dumlupınar	2006	44	Sarı Başak	2013
18	Fata Sel	-	45	Akçakale-2000	2002
19	Selçuklu-97	1997	46	Özberk	2005
20	Meram-2002	2002	47	Pınar-2001	2001
21	Tunca 79	1979	48	Zenit	2001
22	Gökgöl 79	1979	49	Svevo	2001
23	Diyarbakır-81	1987	50	Levante	2011
24	Ceylan 95	1995	51	Saragolla	2011
25	Sarı çanak 98	1998	52	Maestrale	2012
26	Altın toprak 98	1998	53	Bisante	2012
27	Aydın-93	2002			
No	**Genbank accession no**	**Emmer wheat genotypes**			
1	RXN Ab.146/12	*Triticum dicoccum* var. *haussknechtianum*			
2	RXN Ab.147/12	*Triticum dicoccum* var. *haussknechtianum*			
3	RXN Ab.148/12	*Triticum dicoccum* var. *haussknechtianum*			
4	RXN Ab.149/12	*Triticum dicoccum* var. *haussknechtianum*			
5	RXN Ab.153/12	*Triticum dicoccum* var. *aeruginosum*			
6	RXN Ab.154/12	*Triticum dicoccum* var. *aeruginosum*			
7	RXN Ab.156/12	*Triticum dicoccum* var. *haussknechtianum*			
8	RXN Ab.157/12	*Triticum dicoccum* var. *aeruginosum*			
9	RXN Ab.158/12	*Triticum dicoccum* var. *haussknechtianum*, var. *aeruginosum*			
10	RXN Qob. 2/2016	*Triticum dicoccum* var. *atratum*			
11	RXN Qob. 3/2016	*Triticum dicoccum* var. *hausknechtianum*, var. *aeriginosum*			
12	RXN Qob. 4/2016	*Triticum dicoccum* var. *haussknechtianum*			
No	**Polish wheat genotypes**				
1	*Triticum polonicum* var. *rubrosemineum*				
2	*Triticum polonicum* var. *chrysospermum*				
3	*Triticum polonicum* var. *chrysospermum*				
4	*Triticum polonicum* var. *pseudorubrosemineum* var. *nova*				
5	*Triticum polonicum* var. rufescens				
6	*Triticum polonicum* var. *chrysospermum*				
7	*Triticum polonicum* var. *rubrosemineum*				
8	*Triticum polonicum* var. *pseudorubrosemineum* var. *nova*				
9	*Triticum polonicum* var. *chrysospermum*				
10	*Triticum polonicum* var. *pissarevii*				
11	*Triticum polonicum* var. *skalasubovii*				
12	*Triticum polonicum* var. *caryopsirubrum*				
13	*Triticum polonicum* var. *pseudorubrosemineum* var. *nova*				
14	*Triticum polonicum* var. *heydelbergi*				
15	*Triticum polonicum* var. *pseudolevissimum*				
16	*Triticum polonicum* var. *pseudolevissimum*				
17	*Triticum polonicum* var. *chrysospermum*				
18	*Triticum polonicum* var. *rubrosemineum*				
19	*Triticum polonicum* var. *gorskyi*				

For the scoring of disease severity, the double digit scale (00-99) was used (Eyal et al., 1987) which the first digit shows intensity of disease same with the Saari-Prescot (0-9) scale (Saari and Prescott, 1975) and the second digit indicate to the leaf surface covered with the pycnidia. The tested tetraploid wheat species were scored at two weeks intervals starting with growth stage of Zadoks 70 to 75 (Zadoks et al., 1974). In the disease evaluations, the highest score was considered for each variety. To compare the all test materials in detail, in addition, the reactions of the each tetraploid wheat species based on the infection types (ITs) were group as immune (I), highly resistant (HR), resistant (R), moderately resistant (MR), moderately susceptible (MS), susceptible (S) and highly susceptible (HS). The constant values for ITs were calculated based on, I = 00, HR = 1-14, R = 15-34, MR = 35-44, MS = 45-64, S = 65-84, HS = 85-99 (Dalvand et al., 2014). Statistical data analysis was performed to determine the significance of the differences among the tetraploid wheat species for disease scoring. The variance analysis and comparing the average disease score values were analyzed in XLSTAT software (Addinsoft, New York, USA).

RESULTS

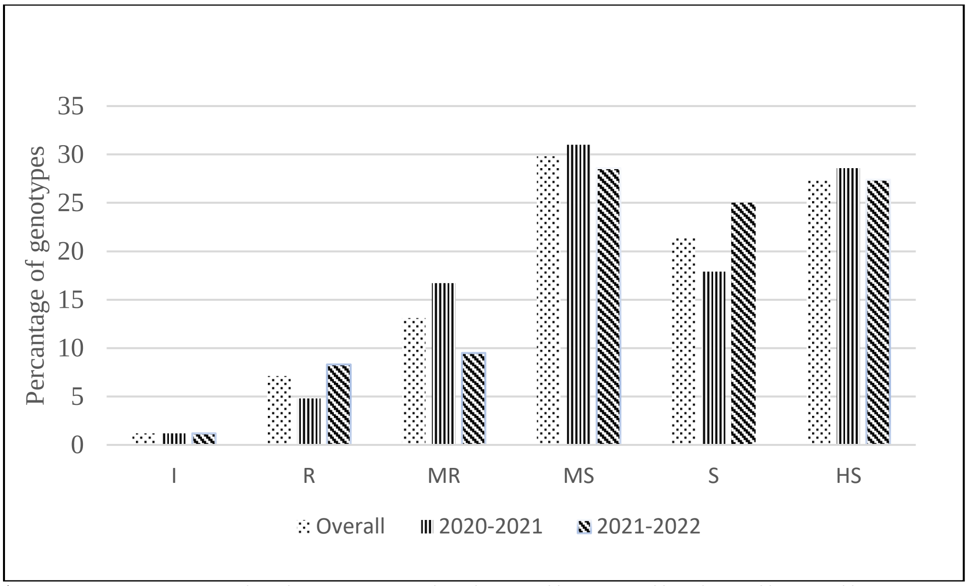
Impact of the STB in 84 tetraploid wheat species were evaluated on natural infection conditions in 2020-2021 and 2021-2022 seasons. Data analysis showed that different ITs among tested wheat species were observed in two growing seasons. The analysis of variance (ANOVA) revealed that tetraploid wheat species had significant difference in terms of STB infection in adult plant stage (p<0.001). On the other hand Genotype x year interaction and among years were not statistically importance. Least significant difference (LSD) value for tetraploid wheat species were calculated as 6.92 (Table 2).

Table 2. Analysis of variance for Septoria tritici blotch reaction of the tetraploid wheat varieties in two years

Source of variance	**d.f.**	**Mean squares**	**F**
Genotype	83	1911.10	82.38***
Year	1	26.30	1.13^{ns}
Replication	1	146.68	6.32^{*}
Genotype x year	83	17.57	0.76^{ns}
Error	167	23.20	
LSD value	6.72		

*p<0.05, ***p <0.001, ns: non-significant

A total of 84 tetraploid wheat species comprising 53 of *T. durum*, 12 of *T. dicoccum* and 19 of *T. polonicum* average disease severity changed from 00 to 96.5 and 00 to 95.5 in 2020-2021 and 2021-2022 growing seasons respectively. In addtion, susceptible control “Morrocco” In the research, it was determined that 46.4% of the tested genotypes showed susceptible and highly susceptible reactions in 2020-2021 growing season, while 18 (21.4%) of the genotypes determined resistant and moderately resistant reactions. In addition, 44 (52.4%) of the genotypes showed susceptible and highly susceptible reactions, and 15 (17.8%) showed resistant and moderately resistant reactions in 2021-2022 season (Figure 1). When the tetraploid wheat species were evaluated separately, among the durum wheat varieties, the lowest disease severity was observed in Akbaşak 073/144, Yelken 2000, and Fırat-93 varieties (ds: 30) in 2020-2021 season, while the highest disease severity was determined in the Şahinbey variety (ds: 82) (Table 3). In the same year, while 19 (22.6%) and 38 (45.3%) of tested durum wheat varieties showed susceptible and moderately susceptible reactions, 21 (24.5%) and 6 (7.5%) of them had moderately resistant and resistant reactions respectively. In 2021-2022 season, the lowest disease severity was found in the Yelken 2000 variety (ds: 27.5), while the highest disease score was observed in the Gediz-75 variety (ds: 78). Based on the infection types of durum wheat varieties, more than of 70% had moderately susceptible (39.6%) and susceptible reactions (32.1%), 28.3% of them had moderately resistant (15.1%) and resistant reactions (13.2%) (Table 3). STB severity among the emmer wheat genotypes ranged from 0 to 93, and among of them, one genotype *T. dicoccum* var. *haussknechtianum* was detected immune reaction while 66.6% of emmer genotypes were to susceptible and highly susceptible reaction (Table 3). Also, none of them was no resistant reaction. The nearest genotypes with one emmer genotype showing an immune reaction were Altıntaş 95, Fırat 93 and Yelken 2000. Evaluated to the Polish wheat genotypes, on the other hand, were determined to be highly suceptible reaction to STB (>ds: 90). Furthermore, all Polish wheat genotypes and two emmer wheat genotypes (*Triticum dicoccum* var. *hausknechtianum*, var. *aeriginosum* were statistically same group. Both years were evaluated, while 27.4%, 21.4% and 29.8% of the tested wheat species were highly susceptible, susceptible and moderately susceptible reactions to STB disease, 13.1% and 7.1% of them moderately resistant and resistant reactions, respectively (Figure 1).



*I: Immune; R: Resistant; MR: Moderately resistant; MS: Moderately susceptible; S: Susceptible and HS: Highly susceptible

Figure 1. Reactions of tetraploid wheat species to septoria tritici blotch disease in two growing seasons.

Table 3. Disease severity (DS) and infection types (ITs) of 84 tetraploid wheat species under natural STB infection conditions in two years.

Tetraploid wheat species	2021		2022		Overall	
	DS	ITs	DS	ITs	DS	ITs
Akbaşak 073/144	30	R	34.5	R	32.25^{ae-ah}	R
Kunduru 414/44	55	MS	51.5	MS	53.25^{q-t}	MS
Berkmen 469	58	MS	61.5	MS	59.75^{k-q}	MS
Çakmak 79	37	MR	31.5	R	34.25^{ad-ah}	R
Kızıltan 91	36	MR	37	MR	36.5^{ab-ag}	MR
Altın 40/98	37	MR	34	R	35.5^{ac-ag}	MR
Yılmaz 98	44	MR	41.5	MR	42.75^{w-ab}	MR
Ankara 98	37	MR	44	MR	40.5^{x-ad}	MR
Çeşit-1252	57	MS	62.5	MS	59.75^{k-q}	MS
Mirzabey 2000	60	MS	66.5	S	$63.25^{ı-o}$	MS
Eminbey	68.5	S	65	S	66.75^{g-j}	S
İmren	54	MS	61	MS	57.5^{n-r}	MS
Kunduru 1149	55	MS	50.5	MS	52.75^{r-u}	MS
Altıntaş 95	32	R	28	R	30^{ag-ah}	R
Kümbet 2000	40	MR	43	MR	41.5^{x-ac}	MR
Yelken 2000	30	R	27.5	R	28.75^{ah}	R
Dumlupınar	54	MS	58.5	MS	56.25^{p-s}	MS
Fata Sel	42	MR	46	MS	44^{w-y}	MR
Selçuklu-97	60	MS	66.5	S	$63.25^{ı-o}$	MS
Meram-2002	42	MR	49.5	MS	45.75^{v-x}	MS
Tunca 79	46	MS	41	MR	43.5^{w-z}	MR
Gökgöl 79	55	MS	51	MS	53^{r-t}	MS
Diyarbakır-81	46.5	MS	55	MS	50.75^{s-v}	MS
Ceylan 95	54	MS	62.5	MS	58.25^{m-r}	MS
Sarı çanak 98	62	MS	70.5	S	66.25^{g-k}	S
Altın toprak 98	75	S	76.5	S	75.75^{de}	S
Aydın-93	72	S	67.5	S	$69.75^{e-ı}$	S
Fırat-93	30	R	31.5	R	30.75^{af-ah}	R
Artuklu	73	S	70	S	71.5^{e-g}	S
Eyyubi	75	S	73.5	S	74.25^{d-f}	S
Şahinbey	82	S	76	S	79^{cd}	S
Zühre	52	MS	56.5	MS	54.25^{p-t}	MS
Güney Yıldızı	65	S	69.5	S	$67.25^{g-ı}$	S
Gediz-75	81	S	78	S	79.5^{cd}	S
Ege 88	54	MS	54.5	MS	54.25^{p-t}	MS
Salihli 92	70	S	72.5	S	71.25^{e-g}	S
Şölen 2002	74	S	69.5	S	71.75^{e-g}	S

Tüten 2002	66	S	70	S	$68^{f-ı}$	S
GAP	58	MS	63	MS	60.5^{j-p}	MS
Turabi	64	MS	64	MS	64^{h-n}	MS
Sham-1	66	S	72.5	S	$69.25^{e-ı}$	S
Amanos-97	56	MS	57.5	MS	56.75^{o-s}	MS
Fuatbey 2000	35	MR	30.5	R	32.75^{ae-ah}	R
Sarı Başak	60	MS	68.5	S	64.25^{h-m}	MS
Akçakale-2000	58.5	MS	60	MS	59.25^{l-r}	MS
Özberk	55	MS	54	MS	54.5^{p-t}	MS
Pınar-2001	38	MR	35.5	MR	36.75^{aa-af}	MR
Zenit	50	MS	47.5	MS	48.75^{t-w}	MS
Svevo	44	MR	48.5	MS	46.25^{u-x}	MS
Levante	62	MS	71.5	S	66.75^{g-j}	S
Saragolla	52	MS	56	MS	54^{p-t}	MS
Maestrale	36	MR	38	MR	37^{z-af}	MR
Bisante	41	MR	36	MR	38.5^{y-ae}	MR
T. dicoccum var. *hausskneсhtianum*	0	I	0	I	$0^{aı}$	I
T. dicoccum var. *haussknechtianum*	56.5	MS	50.5	MS	53.5^{q-t}	MS
T. dicoccum var. *haussknechtianum*	65	S	66	S	65.5^{g-l}	S
T. dicoccum var. *haussknechtianum*	72.5	S	67.5	S	70^{e-h}	S
T. dicoccum var. *aeruginosum*	56.5	MS	54	MS	55.25^{p-t}	MS
T. dicoccum var. *aeruginosum*	40.5	MR	46	MS	43.25^{w-aa}	MR
T. dicoccum var. *haussknechtianum*	69.5	S	74	S	71.75^{efg}	S
T. dicoccum var. *aeruginosum*	87.5	HS	81.5	S	84.5^{bc}	S
T. dicoccum var. *haussknechtianum*	93.5	HS	90	HS	91.75^{a}	HS
T. dicoccum var. *atratum*	89.5	HS	92.5	HS	91^{ab}	HS
T. dicoccum var. *hausknechtianum*	92.5	HS	91.5	HS	92^{a}	HS
T. dicoccum var. *haussknechtianum*	89	HS	93	HS	91^{ab}	HS
T. polonicum var. *rubrosemineum*	94.5	HS	92.5	HS	93.5^{a}	HS
T. polonicum var. *chrysospermum*	94.5	HS	91	HS	92.75^{a}	HS
T. polonicum var. *chrysospermum*	91.5	HS	93	HS	92.25^{a}	HS
T. polonicum var. *pseudorubrosemineum* var. *nova*	93	HS	91	HS	92^{a}	HS
T. polonicum var. rufescens	92.5	HS	91.5	HS	92^{a}	HS
T. polonicum var. *chrysospermum*	94	HS	90.5	HS	92.25^{a}	HS
T. polonicum var. *rubrosemineum*	92.5	HS	92	HS	92.25^{a}	HS
T. polonicum var. *pseudorubrosemineum* var. *nova*	91.5	HS	90	HS	90.75^{ab}	HS
T. polonicum var. *chrysospermum*	92.5	HS	91.5	HS	92^{a}	HS
T. polonicum var. *pissarevii*	94.5	HS	92.5	HS	93.5^{a}	HS
T. polonicum var. *skalasubovii*	94.5	HS	91.5	HS	93^{a}	HS
T. polonicum var. *caryopsirubrum*	93.5	HS	94.5	HS	94^{a}	HS
T. polonicum var. *pseudorubrosemineum* var. *nova*	93	HS	93	HS	93^{a}	HS
T. polonicum var. *heydelbergi*	91	HS	92.5	HS	91.75^{a}	HS
T. polonicum var. *pseudolevissimum*	95.5	HS	91.5	HS	93.5^{a}	HS
T. polonicum var. *pseudolevissimum*	93.5	HS	94.5	HS	94^{a}	HS
T. polonicum var. *chrysospermum*	96.5	HS	95.5	HS	96^{a}	HS
T. polonicum var. *rubrosemineum*	95.5	HS	95	HS	95.2^{a}	HS
T. polonicum var. *gorskyi*	93	HS	94.5	HS	93.75^{a}	HS

In additon to this, the resistant reactions to STB were determined among the durum wheat varieties including Akbaşak 073/144, Çakmak 79, Altıntaş 95, Yelken 2000, Fırat-93 and Fuatbey 2000. On the other hand, highly susceptible reactions were all polish wheat species and four emmer wheat genotypes. Among the emmer genotypes, subspecies *T. dicoccum* var. *aeruginosum*, was showed moderately resistant reaction and none of them showed resistant reaction.

DISCUSSION

Breeding efforts for resistance and tolerance to biotic stresses have contributed significantly to control of them in the past, and they will continue to facilitate the increase in durum wheat yield without excessive chemical control usage in the future. However, the majority of research conducted worldwide has primarily focused on rusts, head blight, and tan spot diseases (Wivart et al., 2013; Martínez et al., 2007; Kokhmetova et al., 2021). Under field conditions, many pathogens contribute to diseases, and therefore, the consideration of the septoria in tetraploid wheat species should not be overlooked. In this study, some tetraploid wheat species in Türkiye were evaluated at the adult plat stage reaction in two growing season to STB disease that is considered one of the most important and destructive disease of wheat in the world and it is observed routinely in each year. Results of the study showed that, highly phenotypic variation was determined in the tetraploid wheat species to STB. This findings are correlated with different studies conducted by several researchers (Ababa et al., 2022; Ben M’Barek et al., 2022). This variation could be explained by the genetic background among wheat species and climatic conditions. Based on the 00-99 digit scale, lowest disease severity was determined in durum wheat variety Yelken 2000 (ds: 28.75) and one emmer genotype while highest disease severity was in Polish wheat species (ds>90) in two growing seasons under field conditions. Along with these findings, tested wheat species were grouped into seven categories including immune, resistant, moderately resistant, moderately susceptible and highly susceptible reactions. This finding are not similar with the study conducted by Omrani et al. (2023) who stated that three main groups of resistant, moderately resistant, and moderately susceptible reactions were reported in 44 commercial Iranian wheat varieties.

In a study conducted by Gultyaeva et al. (2020), host resistance to rust, glume blotch, tan spot, and STB was evaluated in 21 spring durum wheat accessions from Russia and Kazakhstan in 2017 and 2018 growing seasons. They stated that some accessions observed resistance to rust, glume blotch, and leaf blotch, and similarly were also resistant to rust or spots. On the other hand, it is difficult to control of the leaf spot diseases complex in wheat including tan spot (caused by *Pyrenophora tritici repentis*), Stagonospora nodorum blotch (caused by *Parastagonospora nodorum*) and Septoria tritici blotch (caused by *Zymoseptoria tritici*) hence use of the resistant wheat varieties is the most effective and economical way controlling of leaf spot. To date, 21 resistance genes (Stb) have been identified in common wheat to STB (Brown et al., 2015). In contrast, there have been very few resistance genes identified in durum wheat (Aouini, 2018). Similarly the same researcher revealed that the resistance observed in the “Agile 39” durum wheat landrace. Previous studies have been reported that durum wheat showed highly susceptible reactions to several fungal pathogens (Xu et al., 2004; Singh et al., 2006; Chu et al., 2008). Furthermore, majority of durum wheat varieties are susceptible to leaf spots disease (Gultyaeva et al., 2020). Similarly, only a few emmer and durum wheat genotypes showed resistant reaction to STB in this study. The main reason for this is due to narrow genetic base of durum wheat. Kolesova et al. (2022) stated that wheat relatives from the the N.I. Vavilov Institute of Plant Industry (VIR) collection containing valuable breeding material were evaluated under field conditions three leaf spot diseases and all samples were highly susceptible to Septoria nodorum blotch and Helminthosporium leaf blotch.

CONCLUSION

The results of the current study showed that high diversity was determined on STB resistance when comparing reaction types among tetraploid wheat species. In accordance with this, one emmer genotype showed immune reaction whereas all Polish wheat genotypes used in this study were determined to be highly susceptible reactions under field conditions to STB. In addition, four emmer genotypes showed highly susceptible reactions to STB disease. In overall, 8.3% of the tetraploid wheat genotypes showed immune (1.2%) and resistant (7.1%) reactions in two growing seasons. Considering the results of this study, durum and emmer wheat species showing resistant reaction can be used an indicator of the breeding studies however more detail related of them should be analyzed molecularly which resistance gene/genes contained. Genotyping of resistant durum and emmer genotypes will further reveal their genetic differences or similarities and will also contribute to the identification and mapping of genes that are effective in STB.

Conflict of Interest Statement: The author declares no conflict of interest.

Contribution Rate Statement Summary of Researchers: The author: Conceptualization, formal analysis, investigation, software, validation, writing-original draft, writing-review and editing.

Acknowledgments: The author thanks Dr. Mehmet TEKİN from Akdeniz University, Deparment of Field Crops, for providing tetraploid wheat materials and assistance in field trials.

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