



Wheat Stem Rust Races in Sinop, Turkey**

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ABSTRACT

Stem rust caused by *Puccinia graminis* f. sp. *tritici* is an important disease of wheat in the world. This disease is also common in the Sinop province of Turkey. The pathogen forms new races and these races may overcome the resistance present in wheat cultivars. For sustainable wheat production, identification of the stem races is necessary. During 2016 and 2017, surveys were conducted in wheat-growing areas of Sinop province and from diseased plants, 42 single uredospore pustules were obtained. Using North American differential genotypes stem rust races were identified. The most common race was TTTTF followed by TTKTF, RTTTF, RTKTF, and TTKTC.

1. Introduction

Wheat (*Triticum* spp.) is one of the most important crops in the World. In Turkey, among the cool-season cereals, wheat is planted in more than 70 percent of the areas (Geçit 2016). In Sinop province of Turkey wheat is planted in 181.123 and 190.358 decares of land during 2016 and 2017 with a production of 37.456 and 41.563 tons of yield, respectively (Anonymous, 2020).

Stem rust caused by the basidiomycetous fungus *Puccinia graminis* f. sp. *tritici* is one of the oldest known diseases of wheat (Roelfs et al. 1992). The pathogen forms new races and these races may overcome the resistance present in wheat cultivars. For sustainable wheat production, identification of the stem races is necessary. Race TTKSK caused large epidemics and variants of this race have been identified (Singh et al. 2015). In a study conducted in Turkey 21 different stem rust races have been found (Mert et al. 2012). In their study, race TKTTC was the most common race. Stem rust of wheat caused by *P. graminis* f. sp. *tritici* is common in Turkey (İren 1955; Mert et al. 2012) and in the Sinop province of Turkey (Akci and Karakaya 2017). In this study, wheat stem rust races occurring at the Sinop province of Turkey were determined. The preliminary abstract related to

the race TTTTF from the Gerze district of Sinop was previously published (Akci and Karakaya 2019).

2. Materials and Methods

Surveys were conducted in 2016 and 2017 in the Sinop province of Turkey (Figure 1). In 2016, 31 wheat fields in Saraydüzü, Durağan, Boyabat, and Gerze districts of Sinop province were surveyed. In 2017, 12 wheat fields in the Boyabat district were surveyed. A systematic sampling method was used in survey studies (Aktaş 2001). From diseased plants, 42 single uredospore pustules were obtained. Single uredospore pustules were multiplied on susceptible cv Demir 2000. Inoculation, incubation, and disease evaluation procedures were performed as described by Mert et al. (2012). A 0-4 scale was used for evaluation and race identification was carried out using 20 North American differential cultivars (Tables 1 and 2) (Roelfs and Martens 1988; Jin et al. 2008; Mert et al. 2012)

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** Short communication



Figure 1
Map of Sinop province, Turkey (Anonymous 2021)

Table 1
Stem rust differential genotypes used in this study

	Genotypes	Resistance genes
1	ISr5-Ra CI 14159	<i>Sr 5</i>
2	<i>T. monococcum</i> /8*LMPG-6 DK13	<i>Sr 21</i>
3	Vernstein PI 442914	<i>Sr 9e</i>

4	ISr7b-Ra CI 14165	<i>Sr 7b</i>
5	Lee/6*LMPG-6 DK37	<i>Sr 11</i>
6	ISr6-Ra CI 14163	<i>Sr 6</i>
7	CI 14167/9 *LMPG-6 DK04	<i>Sr 8a</i>
8	Chinese Spring*7/ Marquis 2B	<i>Sr 9g</i>
9	W2691SrTt-1 CI 17385	<i>Sr 36</i>
10	Prelude*4/2/Marquis*6/Kenya 117A	<i>Sr 9b</i>
11	Selection from Webster F3:F4 #6	<i>Sr 30</i>
12	Prelude/8*Marquis*2/2/Esp 518/9	<i>Sr 17</i>
13	ISr9a-Ra CI 14169	<i>Sr 9a</i>
14	ISr9d-Ra CI 14177	<i>Sr 9d</i>
15	W2691Sr10 CI 17388	<i>Sr 10</i>
16	CnsSrTmp	<i>Sr Tmp</i>
17	LcSr24Ag	<i>Sr 24</i>
18	Sr 31(Benno)/6*LMPG-6 DK42	<i>Sr 31</i>
19	Trident Sr38	<i>Sr 38</i>
20	McNair 701	<i>Sr Mcn</i>

Table 2

Puccinia graminis f. sp. *tritici* (*Pgt*) code for the 20 *Pgt* differential hosts for *Pgt* in ordered subsets of four (adapted from Roelfs and Martens (1988) and Jin et al (2008))

Subset* and <i>Pgt</i> code	Infection types produced on host lines with <i>Sr</i> resistance genes				
1st 4 genotypes	<i>Sr5</i>	<i>Sr21</i>	<i>Sr9e</i>	<i>Sr7b</i>	
2nd 4 genotypes	<i>Sr11</i>	<i>Sr6</i>	<i>Sr8a</i>	<i>Sr9g</i>	
3rd 4 genotypes	<i>Sr36</i>	<i>Sr9b</i>	<i>Sr30</i>	<i>Sr17</i>	
4th 4 genotypes	<i>Sr9a</i>	<i>Sr9d</i>	<i>Sr10</i>	<i>SrTmp</i>	
5th 4 genotypes	<i>Sr24</i>	<i>Sr31</i>	<i>Sr38</i>	<i>SrMcn</i>	
B	Resistant	Resistant	Resistant	Resistant	Resistant
C	Resistant	Resistant	Resistant	Resistant	Susceptible
D	Resistant	Resistant	Susceptible	Resistant	Resistant
F	Resistant	Resistant	Susceptible	Susceptible	Susceptible
G	Resistant	Susceptible	Resistant	Resistant	Resistant
H	Resistant	Susceptible	Resistant	Susceptible	Susceptible
J	Resistant	Susceptible	Susceptible	Resistant	Resistant
K	Resistant	Susceptible	Susceptible	Susceptible	Susceptible
L	Susceptible	Resistant	Resistant	Resistant	Resistant
M	Susceptible	Resistant	Resistant	Susceptible	Susceptible
N	Susceptible	Resistant	Susceptible	Resistant	Resistant
P	Susceptible	Resistant	Susceptible	Susceptible	Susceptible
Q	Susceptible	Susceptible	Resistant	Resistant	Resistant
R	Susceptible	Susceptible	Resistant	Susceptible	Susceptible
S	Susceptible	Susceptible	Susceptible	Resistant	Resistant
T	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible

**Pgt* code consists of the designation for subset 1 followed by subset 2, etc. Scale values 0, , 1, 2 were considered as resistant (low) and scale values 3 and 4 were considered as susceptible (high). For example, race TTTTF is virulent on *Sr5*, *Sr21*, *Sr9e*, *Sr7b*, *Sr11*, *Sr6*, *Sr8a*, *Sr9g*, *Sr9b*, *Sr30*, *Sr17*, *Sr9a*, *Sr9d*, *Sr10*, *Sr36*, *SrTmp*, *Sr38* and *SrMcn* resistance genes and avirulent on *Sr24* and *Sr31* resistance genes. Low (resistant) and high (susceptible) infection types indicate an incompatible and a compatible host-pathogen interaction, respectively

3. Results and Discussion

In 2016, stem rust was found in 25 fields (Akci and Karakaya 2017). In 2017, stem rust was present in 7 fields. In 2016 and 2017, 42 single uredospore pustules were obtained from wheat fields in Saraydüzü, Durağan, Gerze, and Boyabat districts of Sinop province and stem rust races were determined using North American differential cultivars. The most common race in Sinop province was TTTTF followed by TTKTF, RTTTF, RTKTF, and TTKTC. In 2016, from Saraydüzü district stem rust races TTTTF (3 isolates), TTKTF (2 isolates) and TTKTC (1 isolate), from Durağan district RTKTF (2 isolates), TTTTF (1 isolate) and RTTTF (1 isolate), from Gerze district TTTTF (2 isolates), from Boyabat district TTTTF (13 isolates), TTKTF (5 isolates) and RTTTF (3 isolates) were found. In 2017, from Boyabat district race TTTTF (9 isolates) was determined (Table 3, Figure 2).

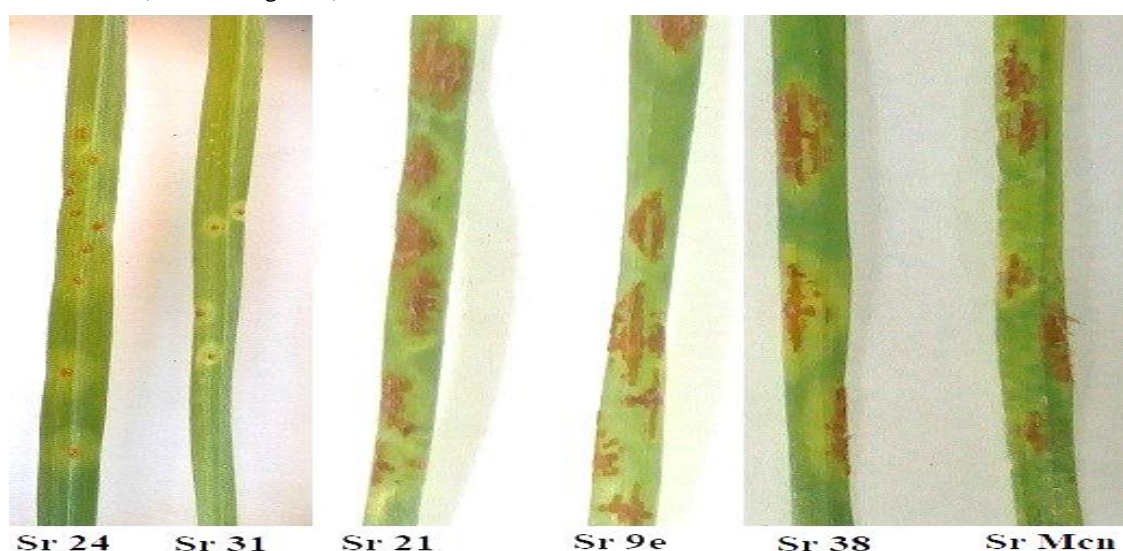


Figure 2

Reactions of stem rust differential genotypes possessing *Sr24*, *Sr31*, *Sr21*, *Sr9e*, *Sr38*, and *SrMcn* resistance genes to race TTTTF

The percentage of the race TTTTF was 67. The percentages of TTKTF, RTTTF, RTKTF, and TTKTC were 17, 9, 5, and 2, respectively. Differential set genotypes possessing the resistance genes *Sr24* and *Sr31* were resistant to all isolates. Genotypes possessing the resistance genes *Sr9e*, *Sr38*, and *Sr36* showed different reactions to isolates. Genotypes possessing the resistance genes *Sr5*, *Sr6*, *Sr7b*, *Sr8a*, *Sr9g*, *Sr9b*, *Sr9a*, *Sr9d*, *Sr10*, *Sr11*, *Sr17*, *Sr21*, *Sr30*, *SrTmp* and *SrMcn* exhibited susceptible reactions to all isolates. A total of five stem rust races were determined in Sinop wheat fields. Race TTTTF was the most common race followed by races TTKTF, RTTTF, RTKTF, TTKTC. Akci and Karakaya (2021) determined the stem rust races originating from *Berberis* spp. and wheat plants in the neighboring province of Kastamonu, Turkey. In their study, from *Berberis* spp., stem rust races TTTTF, RTTTF,

Table 3

Wheat stem rust races determined in Sinop province of Turkey during 2016 and 2017

Location	Stem rust race	2016	2017
Saraydüzü	TTTTF	3 isolates	
	TTKTF	2 isolates	
	TTKTC	1 isolate	
Durağan	RTKTF	2 isolates	
	TTTTF	1 isolate	
	RTTTF	1 isolate	
Gerze	TTTTF	2 isolates	
Boyabat	TTTTF	13 isolates	9 isolates
	TTKTF	5 isolates	
	RTTTF	3 isolates	

RTTTC, TTTTC, and TTKTF were reported. From wheat plants, stem rust races TTTTF, TTKTF, TTTTC, TTKTC, RTTTF, and RTTTC were reported. From both *Berberis* spp. and wheat plants, the race TTTTF was the most commonly encountered race. Stem rust races TTTTF, TTKTF, and RTTTF were also found in our present study. Mert et al. (2012) determined the stem rust races occurring in Turkey. A total of 21 stem rust races were found. Stem rust race TKTTC was found as the most common race. In their study, race RTKTF was reported from Kayseri, Yozgat, Sivas, and Erzincan provinces, and race RTTTF was reported from Kastamonu province of Turkey. The researchers identified 6 stem rust races in 2007 and 18 stem rust races in 2008.

Lemma et al. (2015) and Abera et al. (2018) reported the race TTTTF from Ethiopia. This race was also reported from Sicily and mainland Italy (Patpour

et al. 2018), Iran (Afshari et al. 2015; Roohparvar and Omrani 2018), and Kenya (Wanyera et al. 2018).

Stem rust races TTTTF, TTKTF, RTTTF, RTKTF, and TTKTC were found in our current study. Race TTTTF was the most common race. This race is virulent on all resistance genes with the exception of *Sr24* and *Sr31*. Especially this race should be monitored in the region and wheat cultivars resistant to race TTTTF should be developed.

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5. References

- Abera EH, Heyi NB, Wolderufael GW, Tsegab T (2018). Virulence diversity of wheat stem rust (*Puccinia graminis* f. sp. *tritici*) in Ethiopia in 2016 main cropping season. BGRI Workshop, 14-17 April 2018. Marrakech, Morocco.
- Afshari F, Aghaee M, Kamali MRJ, Roohparvar R, Malihpour A, Khodarahmei M, Ebrahimbejad Sh, Aghnum R, Chaichi M, Dadrezaei T, Dalvand M, Dehghan M A, Zakeri AK, Shahbazi K, Safavi SA, Tabatabaei N, Atahoseini M, Nabati E, Hooshyar R, Yasaei M, Nasrollahi N, Mehrabi R, Tabib-Ghaffary M, Hashami M, Patpour M, Bayat Z (2015). Surveillance and Pgt race analysis in Iran, 2014. 2015 BGRI Workshop, 17-20 September, Sydney, Australia.
- Akci N, Karakaya A (2017). Distribution of stem rust (*Puccinia graminis* f. sp. *tritici*) in Sinop, Turkey. *Works of the Faculty of Agriculture and Food Sciences University of Sarajevo* Vol. XLII, 67/2: 190-195.
- Akci N, Karakaya A (2019). Detection of wheat stem rust race TTTTF in Turkey. Second International Conference on Advances in Plant Sciences, ICAPS 2019, 25-26 April 2019. Sarajevo, Bosnia and Herzegovina.
- Akci N, Karakaya A (2021). *Puccinia graminis* f. sp. *tritici* races identified on wheat and *Berberis* spp. in northern Turkey. *Indian Phytopathology* (in press).
- Aktaş H (2001). Önemli hububat hastalıkları ve sürvey yöntemleri. T.C. Tarım ve Köyişleri Bakanlığı. Tarımsal Araştırmalar Genel Müdürlüğü. Bitki Sağlığı Araştırmaları Daire Başkanlığı, 74 s., Ankara.
- Anonymous (2020). Website: www.tuik.gov.tr (Access date: 06.05.2020).
- Anonymous(2021).Website: https://tr.wikipedia.org/wiki/Sinop%27un_il%C3%A7eleri#/media/Dosya:Sinop_districts.png (Access date: 10.01.2021).
- Geçit HH (2016). Serin İklim Tahılları (Buğday, Arpa, Yulaf, Çavdar, Triticale). Ankara Üniversitesi, Ziraat Fakültesi Yayınları, Yayın no: 1640, Ders Kitabı: 591.
- İren S (1955). Orta Anadolu hububat bölgelerinde kara pas mantarının önemi, epidemisi haline geçme imkânları, ırkları, mukavim çeşitler yetiştirmede ırkların rolü ve ara bitkileri üzerinde araştırmalar. Ziraat Vekâleti. Ankara Ziraat Mücadele Enstitüsü. Güzel İstanbul Matbaası, 101 s., Ankara.
- Jin Y, Szabo LJ, Pretorius ZA, Singh RP, Ward R, Fetch T (2008). Detection of virulence to resistance gene *Sr24* within race TTKS of *Puccinia graminis* f. sp. *tritici*. *Plant Disease* 92: 923-926.
- Lemma A, Woldeab G, Semahegn Y (2015). Virulence spectrum of wheat stem rust (*Puccinia graminis* f. sp. *tritici*) in the eastern Showa of Central Ethiopia. *Advances in Crop Science and Technology* S1:008. doi: 10.4172/2329-8863.1000S1-008.
- Mert Z, Karakaya A, Düşünceli F, Akan K, Çetin L (2012). Determination of *Puccinia graminis* f. sp. *tritici* races of wheat in Turkey. *Turkish Journal of Agriculture and Forestry* 36: 107-120.
- Patpour M, Hovmöller MS, Hansen JG, Justesen AF, Thach T, Rodriguez-Algab J, Hodson D, Randazzo B (2018). Epidemics of yellow and stem rust in Southern Italy 2016-2017. BGRI Workshop, 14-17 April 2018. Marrakech, Morocco.
- Roelfs AP, Martens JW (1988). An international system of nomenclature for *Puccinia graminis* f. sp. *tritici*. *Phytopathology* 78:526-533.
- Roelfs AP, Singh RP, Saari EE (1992). Rust diseases of wheat: Concepts and methods of disease management. CIMMYT, Mexico.
- Roohparvar R, Omrani A (2018). Race analysis of *Puccinia graminis* f. sp. *tritici* led to identification of the new race TTKTK, affecting *Sr31* and *SrTmp*, in Iran. BGRI Workshop, 14-17 April 2018. Marrakech, Morocco.
- Singh RP, Hodson DP, Jin Y, Lagudah ES, Ayliffe MA, Bhavani S, Rouse MN, Pretorius ZA, Szabo LJ, Huerta-Espino J, Basnet BR, Lan C, Hovmöller MS (2015). Emergence and spread of new races of wheat stem rust fungus: Continued threat to food security and prospects of genetic control. *Phytopathology* 105:872-884.
- Wanyera R, Wanga H, Kinyanjui P, Sridhar B, Fetch T (2018). Report on rust incidence and races identified in Kenya during 2016 surveys. BGRI Workshop, 14-17 April 2018. Marrakech, Morocco.