Khazar Journal of Science and Technology
Volume 3 №1 2019, 27-37

DOI: 10.5782/2520-6133.2019.3.1.27

Race Analysis of *Puccinia Striiformis* f.sp. *Tritici* in Iran

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Abstract

Globally, wheat is an important crop; as a strategic plant it occupies the largest area of cultivation. *Puccinia striiformis* f.sp. *tritici,* known as yellow rust, caused the embrace damage and epidemic in Iran. Resistance cultivars are known to be the best way to control and prevent the spread of rust. This research studied the genetics of the pathogenicity of 26 isolates of stripe rust from different important wheat-growing areas in Iran; 56 differential and isogenic lines were used with a Bolani susceptible check, under greenhouse condition. Race 6E6A+,*Yr27* from Neishabour (Eshgh Abad) and 7E22A+,*Yr27* from Kermanshah were found to be less aggressive races in this research and races 206E182A+,*Yr27* from Islam Abad, 207E190A+,*Yr27* from Fars and race 231E150A+,*Yr27* from Mashhad, with more than 19 known wheat genes, were the most aggressive races. Results of this research were that virulence was observed on plants with genes *Yr1, Yr2, Yr3, Yr6, Yr7, Yr8, Yr9, Yr18, Yr21, Yr25, Yr26, Yr28, Yr29, Yr31, Yr32, YrSU, YrND, YrCV* and *YrA*. No virulence was detected on plants with genes *Yr4, Yr5, Yr10, Yr15, Yr24* and *YrSP*.

Keywords: wheat, stripe rust, resistance cultivars, aggressive, virulence

Introduction

Yellow rust (stripe), caused by *Puccinia striiformis,* is one of the most important diseases that influence and reduce wheat production. Yellow rust affected 20 to 40 percent of wheat production from 1999 to 2004 in Central Asia (Morgounov et al., 2004). Wheat (*Triticum aestivum* L.) is a strategic cereal with a direct role in the provision of food for humans and an indirect role in the production of animal protein. Wheat breeding programmes aim to improve yield potential, disease resistance and wheat quality. The most practical and environmentally friendly means of protecting wheat crops against rust diseases is the use of resistant cultivars (FAO, 2014). Stripe rust can cause 100% loss of yield if infection occurs very early and the disease continues to develop through the growing season (Chen, 2005). Afshari (2013) has reported that 41 races were determined from 104 isolates in greenhouse conditions from 2008 to 2010 in Iran. Races 6E6A+, 6E10A+ and 6E0A+ were more common. Race 0E0A+ was less aggressive than races 166E158A+ and 134E158A+ with virulence on 11 known genes. "Virulence on plant/s with gene/s *Yr1, Yr2, Yr4, Yr6, Yr7, Yr8, Yr9, Yr10, Yr25, Yr27, YrSU, YrSD, YrND, Yr3, Yr2+, Yr6+, Yr9+, Yr7+, YrCV* and *YrA* was detected". "The majority of isolates with high frequency (more than 70%) displayed virulence on plant/s with *Yr2, Yr7, Yr9* and *YrA* genes. No virulence was detected on plant/s with *Yr3, Yr5* and *YrSP*. In greenhouse tests, the frequency of virulence to wheat genotypes with *Yr1, Yr4, Yr10, YrCV* (32+) and *YrSD* gene was less than 7%. Frequency of virulence to other wheat genotypes was between 8 and 100%" (Afshari, 2013).

Pornamazeh collected 37 isolates of yellow rust pathogen from the most important wheat-growing areas in Iran. The results showed that the race 166E254A+,*Yr27*+ with 62.50% pathogenesis was the most aggressive race from Torogh (Mashhad), and the race 6E134A+ with 33.34% pathogenesis factor was the weakest race from Zarghan1. According to these results, for all the plants containing genes *Yr2, Yr6, Yr7, Yr9, Yr18, YrA* virulence was observed from all isolates. Plants containing genes *Yr1, Yr4, Yr5, Yr10, Yr15, YrSU* were effective against all isolates (Pornamazeh et al., 2013). Dalvand et al. (2013) conducted a survey over two years (2010–2011 and 2011–2012) in Khuzestan province in the south of Iran (warm zone) using a trap nursery, which included 41 lines of standard sets of stripe rust with different genes and Bolani and morocco as susceptible checks; data showed that virulence in genes included *Yr6, Yr7, Yr9, Yr27* and *YrA*. For genes *Yr1, Yr3, Yr4, Yr5, Yr8, Yr10, Yr15, YrCV, YrND, YrSU, YrSP* and *YrSD* virulence was not detected. In Turkey in 2009-2011, experiments concluded that *Puccinia striiformis* is virulent in *Yr2, Yr6, Yr7, Yr9, Yr18, Yr27, Yr28, and Yr31* and avirulent in *Yr1, Yr3, Yr4, Yr5, Yr8, Yr10, Yr15, Yr17, YrSP, YrCV* (Tekdal et al., 2012). Again, in Turkey, 54 isolates were differentiated into 27 and 45 races using 20 World and 20 US wheat differentials, respectively. None of the isolates were virulent on *Yr5, Yr10, Yr15* or Moro, which carries *Yr10* and *YrMor* (Sharma-Poudyal et al., 2013). Due to the possible emergence of new races of yellow rust and disease spreading quickly worldwide which could cause enormous damage, it is essential to manage breeding programmes based on genetical knowledge of the pathogenicity of pathogens and relationships between pathogen and host. As has been proven, many resistance genes have prevented epidemics of yellow rust. Such a resistance gene can be identified by persistent monitoring and examining yellow rust. This study was carried out to identify genes in wheat resistant to stripe rust, in order to prevent epidemics of yellow rust and to use these genes in breeding programmes.

Materials and methods

In this research, various isolates of yellow rust from infected wheat leaves were collected from 26 regions of Iran (Fig. 1) and transferred to the Seed and Plant Improvement Institute, Karaj-Iran. Each sample was then inoculated in the seedlings with susceptible Bolani. In order to determine the pathogenicity of pathogens and gene analysis, 56 differential sets and isogenic lines of wheat were used (Table 1). Inoculation was with a mixture of yellow rust urediniospores and industrial oil Tween 20 and spread by air-pump into Bolani leaves surface. Inoculation was done in 12 step of the Zadoks scale (Zadoks et al., 1974). In order to germinate spore, pots were kept in a cold-room for 24 hours at 10 °C and 100 per cent humidity. The pots were then transferred to a greenhouse with 60 to 70 per cent humidity, at 18°C and 16000 lux for 16 hour days. After 17 days, types of infection were noted by the MacNeal method on a scale of 0 to 9 (McNeal et al., 1971). Determination of isolate race was carried out according to the study described by Johnson et al. (1972) (Table 2).

Table 1. Differential sets and the isogenic lines of wheat

No.	Differential set World Series	Resistance genes	*No.*	Differential set World Series	Resistanc e genes
1	Chinese 166	*Yr1*	28	Yr6/6*Avocet 'S'	*Yr6*
2	Lee	*Yr7*	29	Yr7/6*Avocet 'S'	*Yr7*
3	Heines kolben	*Yr2,Yr7*	30	Yr8/6*Avocet 'S'	*Yr8*
4	Vilmorin 23	*Yr3*	31	Yr9/6*Avocet 'S'	*Yr9*
5	Moro	*Yr10*	32	Yr10/6*Avocet 'S'	*Yr10*
6	Strubes Dikkopf	*YrSd*	33	Yr15/6*Avocet 'S'	*Yr15*
7	Suwon 92/omar	*YrSU*	34	Yr17/6*Avocet 'S'	*Yr17*
8	Clement	*Yr2,Yr9,+*	35	Yr18/6*Avocet 'S'	*Yr18*
9	*Triticum spelta* var.*album*	*Yr5*	36	Yr24/6*Avocet 'S'	*Yr24*
	European Series		37	Yr26/6*Avocet 'S'	*Yr26*
10	Hybrid 46	*Yr4*	38	Yr27/6*Avocet 'S'	*Yr27*

11	Reichersberg 42	*Yr7+*	39	Yr32/6*Avocet ’S’	*Yr32*
12	Heines Peko	*Yr2,Yr6,+*	40	YrSP/6*Avocet ’S’	*YrSP*
13	Nord desprez	*YrND*	41	Jupateco 73R	
14	Compare .	*Yr8*	42	Jupateco 73S	
15	Carstens V	*YrCV*	43	Avocet’R’’	*YrA*
16	Spalding Profic	*YrSP*	44	Avocet’S’	
17	Heines VII	*Yr2+*	45	Bolani	
	Australian Series		46	Fielder	*Yr6,Yr20*
18	Avocet ‘R’	*YrA*	47	Thatcher	*Yr7*
19	Kalyansona	*Yr2*	48	Lemhi	*Yr21*
20	Trident	*Yr17+sr38*	49	Tp1295	*Yr25*
21	Yr 15/6* Avocet S	*Yr15*	50	Yr27/6*Avocet’s’	*Yr27*
22	Hugenoot	*Yr25*	51	Ciano79	*Yr27*
23	Selkirk	*Yr27*	52	Opata85	*Yr27+Yr18*
24	Federation *4/ kavakaz	*Yr9*	53	Avocet Yr28	*Yr28*
25	Federation		54	Lalbahador/pavon	*Yr29*
26	Yr 1/6* Avocet ’S’	*Yr1*	55	Avocet-YrA*3/pastor	*Yr31*
27	Yr5/6*Avocet ’S’	*Yr5*	56	Pastor	*Yr31+APR*

Results and discussion

In this research 26 isolates of yellow rust that were collected from different parts of Iran (Fig. 1) were inoculated separately in 56 differential sets and isogenic lines of wheat in greenhouse conditions. Virulence was detected against plants with gene/s *Yr1*, *Yr2*, *Yr3*, *Yr6*, *Yr7*, *Yr8*, *Yr9*, *Yr18*, *Yr21*, *Yr25*, *Yr26*, *Yr28*, *Yr29*, *Yr31*, *Yr32*, *YrSU*, *YrND*, *YrCV* and *YrA*, which were more common in Iran. The research found no virulence against plants with genes *Yr4*, *Yr5*, *Yr10*, *Yr15*, *Yr24* and *YrSP* and they were resistant to all 26 isolates of yellow rust (Table 2). Pathotype analyses by Prashar revealed that yellow rust in the wheat population of India is avirulent against *Yr5*, *Yr10*, *Yr11*, *Yr12*, *Yr13*, *Yr14*, *Yr15*, *Yr24*, *Yr26*, *YrSp* and *YrSk* (Prashar et al., 2015). Consideration of the reactions of differentials and isogenic lines to the *P. striiformisf.sp. tritici* populations during the six years from 2006 to 2012 determined virulence against *Yr2*, *Yr6*, *Yr7*, *Yr8*, *Yr9*, *YrSU*, *Yr17*, *Yr22*, *Yr23*, *Yr24*, *Yr25*, *Yr26*, *YrA* and *Yr27* and avirulence against *Yr1*,*Yr2+*, *Yr3V*, *Yr3a*, *Yr4a*, *Yr4*, *Yr5*, *Yr7+*, *Yr10*, *Yr15*,*Yr16*, *YrCV*, *YrSD* and *YrND* (Safar Ali Safavi et al., 2013). Studies of pathogenicity indicated that effective genes included *Yr1, Yr2+, Yr3, Yr4, Yr5, Yr10, Yr15, Yr24, Yr26, YrSP, YrND, YrSD* and *YrSU* (Omrani et al., 2013). This research indicates that the *Yr1* gene has lost its resistance over the years and could not be used as a resistance gene in most regions in Iran. Although *Yr3* was identified as a resistance gene in previous research, it has virulence in 6 regions of Iran. Compatible infection types 7 to 9 against *Yr1, Yr2, Yr3, Yr4, Yr6, Yr7, Yr9, Yr17, Yr25, Yr32*, and *YrSp* were recorded in samples collected in 2014 from Thrace and Sakarya in Turkey (Mert et al., 2014).

In our research, plants with gene *Yr24* were resistant to all 26 isolates. Other work by Dalvand (et al., 2013) showed that plants with the genes *YrA, Yr6, Yr7, Yr9*, and *Yr27* were susceptible, indicating that these genes are not effective. Results in Pakistan revealed that stripe rust resistance genes *Yr3, Yr5, Yr10, Yr15, Yr26, YrSP and YrCV* were resistant, while *Yr18* displayed moderate susceptibility at all locations. Genes *YrA-, Yr2, Yr6, Yr7, Yr8, Yr9, Yr17, Yr27* and gene combinations Opata (*Yr27+Yr18*) and Super Kauz (*Yr9, Yr27, Yr18*) were found to be susceptible (Bux et al., 2011).

Races collected from Neishabour (Eshgh Abad) and Kermanshah were less aggressive in this research and races from Eslam Abad, Fars and Mashhad were the most aggressive. Soweizy (et al., 2016) reported no pathogenicity recorded in plants carrying the genes *Yr5, Yr10, Y15*, and *YrSP*. Race 132E156A+, *Yr27* of Ahvaz 3 and race 2E2A+ of Mashhad were identified as the most and least aggressive races, respectively. However, the first detection of *Yr24* virulence in *P. striiformis* populations on Chuanmai 42 was by Liu et al. (2010).

Race 6E6A+,Yr27 and 7E22A+,Yr27 which were the least aggressive races in this research have virulence against plants with gene/s *Yr1, Yr2 ,Yr6, Yr7,Yr8,Yr9, Yr17, Yr18,Yr27,YrA,* and races 206E182A+,*Yr27*, 207E190A+, *Yr27* and 231E150A+,*Yr27* which were the most aggressive races have virulence against plants with genes *Yr1, Yr2 ,Yr6 , Yr7 Yr8, Yr9, Yr18, Yr25, Yr26, Yr27, Yr32, YrA, YrSD, YrSU*. The results of monitoring the virulence factors of wheat yellow rust are shown in Table 2.

An investigation of the pathotypes 6E134A+, 6E142A, 6E6A+, 134E142A, 6E158A+, 134E130A+, 6E22A+, 6E130A+ recorded greater frequency of virulence against plants containing the genes *YrA, Yr32, Yr9+, Yr7+, Yr2+, YrSP, YrSD, Yr24, Yr9, Yr8, Yr7, Yr6, Yr2* and the least frequency against the genes *YrSU, YrCV, Yr1, Yr10, Yr5, Yr4, Yr3* in Iran (Afshari, 2008).

Fig. 1. Map of Iran, showing the locations of yellow rust regions.

Table 2. Avirulence/virulence of wheat yellow rust isolates

No.	Region	Race	Avirulence/ Virulence genes
1	Ardebil	134E150 A+, *Yr27*	*Yr1, Yr3, Yr10, YrSD, YrSU, Yr5, Yr4, YrND, YrCV,YrSP, Yr15, Yr24, Yr26 , Yr32, Yr28, Yr31,Yr31+APR/ Yr7, Yr2, Yr9, Yr2.Yr6.+ , Yr8, YrA, Yr17+sr38, Yr25,Yr27, Yr6, Yr18, Yr6.Yr20, Yr21, Yr29*
2	Zarghan	198E154 A+, *Yr27*	*Yr1, Yr3, Yr10, YrSd, Yr5, Yr4, YrSP, Yr15, Yr5, Yr24, Yr26 ,YrSP/ Yr7, Yr2.Yr7, YrSU, Yr2Yr9+, Yr7+, YrND, Yr8 , Yr2+, YrA, Yr17+sr38, Yr25, Yr27, Yr9, Yr6, Yr7, Yr8, Yr17, Yr18, Yr32, Yr6Yr20, Yr21, Yr28, Yr29, Yr31, Yr31+apr*

3	Sari	134E134 A+, *Yr27*	*Yr1, Yr3, Yr10, YrSd, YrSU, Yr5, Yr4, YrND, Yr8, YrCV, YrSP, Yr15, Yr27, Yr8, Yr17, Yr18, Yr24, Yr32, Yr28, Yr29, Yr31+apr/Yr2Yr7, Yr2Yr9+, Yr2Yr6+, Yr2+, YrA, Yr25, Yr9, Yr6, Yr26, Yr7, Yr21, Yr31, Yr2*
4	Mashhad	6E134A+	*Yr1, Yr3, Yr10, YrSd, YrSU, Yr2Yr9+, Yr5, Yr4, YrND, Yr8, YrCV, YrSP, Yr15, Yr27, Yr24, Yr26,Yr8 ,Yr32/ Yr7, Yr2Yr7, Yr7+, Yr2Yr6+, Yr2+, YrA, Yr2, Yr17+sr38, Yr25, Yr9, Yr6, Yr17, Yr18, Yr6,Yr20, Yr21, Yr25, Yr27+Yr18, Yr28, Yr31, Yr31+apr ,Yr29*
5	Kermans hah	70E150A +,Yr27	*Yr1,Yr10,Yr3,YrSD,Yr2Yr9+,Yr5,Yr4,YrND,YrCV,YrSP,Yr 15,Yr24/Yr7,Yr2,YrSU,Yr2Yr6+,Yr8,YrA,Yr17+Sr38,Yr25, Yr27,Yr9,Yr6,Yr17,Yr18,Yr26,Yr32*
6	Karaj	7E158A+ ,Yr27	*Yr3,Yr10,YrSD,YrSU,Yr2Yr9+,Yr5,Yr4,YrCV,YrSP,Yr15,Y r24/Yr1,Yr7,Yr2,Yr2Yr6+,YrND,Yr8,YrA,Yr17+Sr38,Yr25, Yr27,Yr9Yr6,Yr17,Yr18,Yr26,Yr32*
7	Eslam abad	206E182 A+,Yr27	*Yr1,Yr10,YrSD,Yr5,Yr4,YrND,YrSp,Yr15,Yr24/ Yr7,Yr2,Yr3,YrSU,Yr2Yr9+,Yr2Yr6+,Yr8,YrCV,YrA,Yr17+ Sr38,Yr25,Yr27,Yr9,Yr6,Yr7,Yr17,Yr18,Yr26,Yr32*
8	Zarghan2	110E150 A+,Yr27	*Yr1,Yr10,Yr5,Yr4,YrND,YrCV,YrSp,Yr15,Yr24/Yr7,Yr2,Yr3 ,YrSD,Yr2Yr9+,Yr2Yr6+,Yr8,YrA,Yr17+Sr38,Yr25,Yr27,Y r9,Yr6,Yr7,Yr17,Yr18,Yr26,Yr32*
9	Moghan	78E190A +,Yr27	*Yr1,Yr10, YrSD,Yr2Yr9+,Yr5,Yr4,YrSP,Yr15,Yr24 / Yr7,Yr2,Yr3,YrSU,Yr2Yr6+,YrND,Yr8,YrCV,YrA,Yr17+Sr 38,Yr25,Yr27,Yr9,Yr6,Yr17,Yr18,Yr26,Yr32*
10	Mashhad 2	30E150A +,Yr27	*Yr1,YrSD,YrSU,Yr2YR9+,Yr5,Yr4,YrND,YrCV,YrSP,Yr15/ Yr7,Yr2,Yr3,Yr10,Yr7+,Yr2Yr6+,Yr8,YrA,Yr17Sr38,Yr25, Yr27,Yr9,YrYr10,Yr17,Yr18,Yr24,Yr26,Yr32,Yr6Yr20*
11	Brojerd	110E150 A+,Yr27	*Yr1,Yr10,Yr2Yr9+,Yr5,Yr4,YrNd,YrCV,YrSP,Yr15,Yr24/Yr 7,Yr2,Yr3,YrSD,YrSU,Yr7+,Yr2Yr6+,Yr8,Yr2+,YrA,Yr17+ Sr38,Yr25,Yr27,Yr9,Yr6,Yr8,Yr17,Yr18,Yr26,Yr32*
12	Moghan2	102E130 A+	*Yr1,Yr3,Yr10,Yr2Yr9+,Yr5,Yr4,Yr2Yr6+,YrND,Yr8,YrCV, YrSP,Yr17+Sr38,Yr15,Yr25,Yr27,Yr17,Yr24,Yr26/Yr7,Yr2, YrSD,YrSU,Yr7+,Yr2+,YrA,Yr9,Yr6,Yr18,Yr32,Yr6Yr20*
13	Neishabo or (saad abad)	36E128A -,Yr27	*Yr1,Yr7,Yr3,Yr10,YrSU,Yr2Yr9+,Yr5,Yr4,Yr7+,Yr2Yr6+,Y rND,Yr8,YrCV,YrSP,YrA,Yr17+Sr38,Yr15,Yr25,Yr9,Yr6,Yr 17,Yr18,Yr24,Yr26,Yr32/Yr2,YrSD,Yr2+,Yr27,Yr6Yr20*
14	Zarghan3	6E158A+	*Yr1,Yr3,Yr10,YrSd,YrSU,Yr2Yr9+,Yr5,Yr4,YrCV,YrSP,Yr1 5,Yr27,Yr9,Yr24,Yr26,Yr32/Yr7,Yr2,Yr7+,Yr2Yr6+,YrND, Yr8,Yr2+,YrA,Yr17+Sr38,Yr25,Yr6,Yr8,Yr9,Yr17,Yr18,Yr6 Yr20*

15	Khoram abad	71E30A+,Yr27	*Yr3,Yr10,YrSD,Yr2Yr9+,Yr5,Yr4,YrCV,YrSP,Yr2+,Yr17+Sr38Yr15,Yr24,Yr26/Yr1,Yr7,Yr2,YrSU,Yr7+,Yr2Yr6+,YrNd,Yr8,YrA,Yr25,Yr27,Yr9,Yr6,Yr8,Yr18,Yr32,Yr6Yr20*
16	Kermanshah2	7E22A+,Yr27	*Yr3,Yr10,YrSD,YrSU,Yr2Yr9+,Yr5,Yr4,YrND,YrCV,YrSP,Yr2+,Yr17+Sr38,Yr15,Yr25,Yr24,Yr26,Yr32/Yr1,Yr7,Yr2,Yr7+,Yr2Yr6+,Yr8,YrA,Yr27,Yr9,Yr6,Yr8,Yr9,Yr17,Yr18,Yr6Yr20*
17	Fars	207E190A+,Yr27	*Yr10,YrSd,Yr5,Yr4,YrSP,Yr15,Yr24/Yr1,Yr7,Yr2,Yr3,YrSU,Yr2Yr9+,Yr7+,Yr2Yr6+,YrND,Yr8,YrCV,Yr2+,YrA,Yr17+Sr38,Yr25,Yr27,Yr9,Yr6,Yr8,Yr17,Yr18,Yr26,Yr32,Yr6Yr20*
18	Mashhad3	231E150A+,Yr27	*Yr3,Yr10,Yr5,Yr4,YrNd,YrCV,YrSP,Yr17+Sr38,Yr15,Yr17,Yr24/Yr1,Yr7,Yr2,YrSD,YrSU,Yr2Yr9+,Yr7+,Yr2Yr6+,Yr8,Yr2+,YrA,Yr25,Yr27,Yr9,Yr6,Yr18,Yr26,Yr32,Yr6Yr20*
19	Sirjan	198E150A+,Yr27	*Yr1,Yr3,Yr10,YrSD,Yr5,Yr4,YrND,YrCV,YrSP,Yr15,Yr24,Yr32/Yr7,Yr2,YrSU,Yr2Yr9+,Yr7+,Yr2Yr6+,Yr8,Yr2+,YrA,Yr17+Sr38,Yr25,Yr27,Yr9,Yr6,Yr8,Yr26,Yr6Yr20*
20	Zarghan4	134E150A+,Yr27	*Yr1,Yr3,Yr10,YrSD,YrSU,Yr5,Yr4,YrND,YrCV,YrSP,Yr15,Yr24,Yr32/Yr7,Yr2,Yr2Yr9+,Yr7+,Yr2Yr6+,Yr8,Yr2+,YrA,Yr17+Sr38,Yr25,Yr27,Yr9,Yr6,Yr17,Yr18,Yr26,Yr6Yr20*
21	Neishabour (mian jolge)	6E150A+,Yr27	*Yr1,Yr3,Yr10,YrSD,YrSU,Yr2Yr9+,Yr5,Yr4,YrNd,YrCV,YrSP,Yr15,Yr24,Yr26,Yr32/Yr7,Yr2,Yr7+Yr2Yr6+,Yr8,Yr2+,YrA,Yr17+Sr38,Yr25,Yr27,Yr9,Yr6,Yr17,Yr18,Yr6Yr20*
22	Sarvdasht	103E150A+	*Yr3,Yr10,Yr2Yr9+,Yr5,Yr4,YrND,YrCV,YrSP,Yr15,Yr24,Yr26,Yr27,Yr32/Yr1,Yr7,Yr2,YrSD,YrSU,Yr7+,Yr2Yr6+,Yr8,Yr2+,YrA,Yr17+Sr38,Yr25,Yr9,Yr6,Yr17,Yr18,Yr6Yr20*
23	Torbat heidarie	6E150A+,Yr27	*Yr1,Yr3,Yr10,YrSD,YrSU,Yr2Yr9+,Yr5,Yr4,YrNd,YrCV,YrSP,Yr15,Yr24,Yr32/Yr7,Yr2,Yr7+,Yr2Yr6+,Yr8,Yr2+,YrA,Yr17+Sr38,Yr25,Yr27,Yr9,Yr6,Yr17,Yr18,Yr6Yr20*
24	Neishabor (Eshgh abad)	6E6A+,Yr27	*Yr1,Yr3,Yr10,YrSd,YrSU,Yr2Yr9+,Yr5,Yr4,YrND,Yr8,YrCV,YrSP,Yr2+,Yr17+Sr38,Yr15,Yr8,Yr17,Yr24,Yr26,Yr32/Yr7,Yr2,Yr7+,Yr2Yr6+,YrA,Yr25,Yr27,Yr9,Yr6,Yr18,Yr6Yr20*
25	Pol-dokhtar	6E150A+,Yr27	*Yr1,Yr3,Yr10,YrSD,YrSU,Yr5,Yr4,YrND,YrCV,YrSP,Yr15,Yr24,Yr26,Yr32/Yr7,Yr2,Yr2Yr9+,Yr7+,Yr2Yr6+,Yr8,Yr2+,YrA,Yr17+Sr38,Yr25,Yr27,Yr9,Yr6,Yr17,Yr18,Yr6Yr20*
26	Brojerd	14E150A+,Yr27	*Yr1,Yr10,YrSD,YrSU,Yr2Yr9+,Yr5,Yr4,YrND,YrCV,YrSP,Yr17+Sr38,Yr15,Yr17,Yr24/Yr7,Yr2,Yr3,Yr7+,Yr2Yr6+,Yr8,Yr2+,YrA,Yr25,Yr27,Yr9,Yr6,Yr18,Yr26,Yr32,Yr6Yr20*

Conclusion

In view of the emergence of new races of yellow rust it is important to control and monitor resistance genes. In this research, we observed that plants with the genes *Yr4, Yr5, Yr10, Yr15, Yr24* and *YrSP* are totally resistant in all regions of Iran, and it is possible to use them in wheat breeding programmes in Iran.

Acknowledgements

Thanks to the Seed and Plant Improvement Institute for providing facilities for this research.

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