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Evaluation of seedling and adult plant resistance in wheat lines to *Puccinia striiformis* f. sp. *tritici*

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ABSTRACT

Thirty-six promising wheat lines, obtained from SPII, along with susceptible check were studied to assess their seedling and adult plant resistance to yellow rust. The seedling reaction was evaluated in greenhouse by using race 6E150A+,Yr27. Adult plant resistance were also evaluated by measuring of final rust severity (FRS), and coefficient of infection (CI) under natural infection conditions with two times artificial inoculation during 2010 - 2011 cropping season in field plots at Ardabil Agricultural Research Station (Iran). Artificial inoculation in field was carried out by yellow rust inoculum having virulent genes against Yr2, Yr6, Yr7, Yr9, Yr22, Yr23, Yr24, Yr25, Yr26, Yr27, YrA, and YrSU. Results showed that lines M-89-5, M-89-4 and M-88-18 along with susceptible check had the highest values of FRS and CI, therefore were selected as moderately susceptible to susceptible lines. The lines M-88-3, M-88-6, M-88-14, M-88-16, M-89-8, M-89-10 and M-89-11 were susceptible at the seedling stage and had low level infection at adult plant stage. Consequently these lines with low level values of FRS and CI at adult plant stage most probably have durable resistance.

Key words: wheat, seedling resistance, adult plant resistance, yellow (stripe) rust, *Puccinia striiformis* f. sp. *tritici*

INTRODUCTION

Stripe (yellow) rust of wheat, caused by *Puccinia striiformis* Westend. f. sp. *tritici* is important disease of wheat worldwide. This is mainly due to the pathogen's ability to mutate and multiply rapidly and to use its air-borne dispersal mechanism from one field to another and even over long distances [21]. strip rust severely damages wheat production worldwide [18, 12] causing yield losses from 10 to 70% besides affecting the quality of grain and forage [6]. Stripe rust was dominant disease in Central Asian countries in the late 1990s and early 2000s, accounting for yield losses of 20-40% in 1999 and 2000 [1]. During the last decades, several yellow rust epidemics in most of the wheat-growing areas of Iran caused over 30% crop loss and estimated

grain losses were 1.5 million tons and 1.0 million ton in 1993 and 1995, respectively [22]. Stripe rust can cause 100% yield loss if infection occurs very early and the disease continues to develop during the growing season provided the cultivars are susceptible [1].

Control of yellow rust by chemical products is available with new and more effective fungicides like Tilt, Quadris, Stratego, Headline, and Quilt [6], yet, growing resistant cultivars is the most efficient, economical, and environmentally friendly approach to control disease [13]. Two types of resistance have been identified in several cereal-rust pathosystems; hypersensitive or qualitative (race-specific) and quantitative (race-nonspecific) resistance. Deployment of race-specific resistance gene has capable of providing highly effective protection against the disease [20]. This type of resistance, however, is dependent on specific recognition event between the host (R gene products) and the pathogen (Avirulence gene products) that follows the gene- for-gene interactions, as described by Flor [8], it lacks durability [4]. Conversely, race-nonspecific resistance is mainly polygenic, this type of resistance has often been described as slow rusting or partial resistance [15] and is known to be long-lasting and more durable [9].

Genes *Yr2, Yr3, Yr4, Yr6, Yr7, Yr9* And *YrA* are commonly present in breed wheat cultivars developed by CIMMYT. However, none of these genes is globally effective [5]. An alternative for breeders is quantitative resistance. Two types of quantitative resistance, *i. e*, high temperature adult-plant (HTAP) resistance and slow rusting resistance have been intensively investigated [12]. In many cereal-rust pathosystems, the quantitative aspects of cultivar resistance have been described and estimated by means of disease severity at a certain crop development stage, the area under disease progress curve (AUDPC) or by means of apparent infection rate '*r*' and average coefficient of infection (ACI) values for adult plant resistance [5, 16]. Therefore, this study was conducted to characterize 36 promising wheat lines for durable resistance by comparing of their reactions at seedling and adult plant stages.

MATERIALS AND METHODS

The entire trail was subdivided into two experiments. Experiment-1 was conducted on determining of seedling reaction of wheat lines in greenhouse, but the experiment-2 was carried out on evaluating of adult plant resistance of wheat lines under field conditions. More details of two experiments are being explained in following.

Seedling test: Thirty six promising lines (Table1) with susceptible cultivar (Morocco) that obtained from Cereal Department of Seed and Plant Improvement Institute, Karaj, Iran, were used in this study in 2011. The resistance response of seedling was evaluated in green house by planting seeds (5 seeds) of lines in pots which had mixture of soil, peat moss and sand in a 7:5:5 proportions. After 10 days of sowing, inoculation (with race; 6E150A+,Yr27) was conducted by spraying of them with mixture of spores and talcum powder (in 1:4 proportions). The pots subsequently were placed for 24 h in a dark moist chamber at 10˚C and then transferred to a greenhouse at 15- 18˚C and 16 h light. After 14-17 days of inoculation, resistance reaction was recorded based on McNeal et al [14] by scales 0-9. Infection types equal to or higher than 7 were considered virulent, and those less than 7 were considered avirulent.

Field test: This experiment was conducted in Ardabil Agricultural Research Station (Iran) during 2010-2011 cropping year. Each entry was planted in two rows of 1 meter spaced at 30cm apart. Plots were spaced at 65 cm. Artificial inoculation was carried out with Ardabil race populations having virulence on resistance genes *Yr2, Yr6, Yr7, Yr9, Yr22, Yr23, Yr24, Yr25, Yr26, Yr27, YrA,* and *Yr*SU by spraying all test entries and spreader rows with mixture of spores

and talcum powder (in 1:20 proportions), two times after the sun set. Percent severity was recorded when Morocco reached maximum severity based on modified Cobb's scale [17] and reaction based on Roelfs et al [18]. Coefficient of infection (CI) was calculated by multiplying of disease severity (DS) and constant values of infection type (IF). The constant values for infection types were used based on; R=0.1, MR=0.25, M=0.5, MS=0.75, S=1 [16].

RESULTS AND DISCUSSION

Besides study of seedling reaction, different parameters used as criteria to identify genotypes with adult plant resistance under field condition included infection type, final disease severity, and coefficient of infection. Results regarding these parameters are described as under:

Table 1- Pedigree of studied wheat lines for evaluating of resistance reaction during 2010-2011cropping year in Ardabil

No.	Lines	Pedigree/Parents
1	M-88-1	**Parsi**
2	M-88-2	**Sivand**
3	M-88-3	Alvd//Aldan/Ias/3/Flt
4	M-88-4	Alvd//Aldan/Ias/3/Siren
5	M-88-5	Alvd//Aldan/Ias/3/Siren
6	M-88-6	Gv/D630//Ald"s"/3/Azd/4/Flt
7	M-88-7	Gv/D630//Ald"s"/3/Azd/4/Flt
8	M-88-8	Kauz/Stm//Mv17/3/Alvd//Aldan/Ias
9	M-88-9	Alvd/Aldan/Ias*2/3/Bez
10	M-88-10	Alvd/Aldan/Ias*2/3/Bez
11	M-88-11	Passarinho// Fertillo/Vee#5/4/Gv/D630//Ald"s"/3/Azd
12	M-88-12	Soissons/5/Nvd/4/Omid//H7/4P939/3/Omid/Tdo
13	M-88-13	Alvd//Aldan/Ias/3/Gds
14	M-88-14	Kauz/Stm//Pastor/3/Alvd//Aldan/Ias
15	M-88-15	Passarinho/Sids1/3/Alvd//Aldan/Ias
16	M-88-16	Alvand//Aldan/Ias/3/1-73-240/4/Alamoot
17	M-88-17	902 zhong87/Marv
18	M-88-18	Gv/D630//Ald"s"/3/Azd/4/Chamran
19	M-89-1	-
20	M-89-2	-
21	M-89-3	Evwyt2/Azd//Rsh*2/10120/3/Azd//HD2172/V83035
22	M-89-4	Azd/HD 2172//V83035/3/Tjn
23	M-89-5	Azd/HD 2172//V83035/3/Tjn
24	M-89-6	Gv/D630//Ald"s"/3/Azd/4/Seri/avd/3/Rsh//Ska/Afn
25	M-89-7	OASIS/SKAUZ//4*BCN/3/2*PASTOR
26	M-89-8	KAMB1/MNNK1//WBLL1
27	M-89-9	KAUZ/PASTOR//PBW343
28	M-89-10	BABAX/3/OASIS/SKAUZ//4*BCN/4/PASTOR
29	M-89-11	BOW/PRL//BUC/3/LUAN/4/PASTOR/3/KAUZ*2/OPATA//KAUZ
30	M-89-12	CBRD/KAUZ//PARUS/4/KAUZ*2//SAP/MON/3/KAUZ
31	M-89-13	KAUZ/HEVO//CHOIX/3/MILAN
32	M-89-14	OASIS/SKAUZ//4*BCN/3/2*PASTOR
33	M-89-15	TEG/MIAN YANG 20//CHUM18/5*BCN
34	M-89-16	ATTILA/PANDION//ATTILA/2*PASTOR
35	M-89-17	CHEN/AE.SQ//2*OPATA/3/TILHI/4/ATTILA/2*PASTOR
36	M-89-18	Pishtaz/Soissons
37	Morocco	-

Results of seedling reaction

The results of seedling assessment estimated has been listed in Table 2. Twelve lines had resistance reaction and 24 lines had susceptible reaction at seedling stage. Three lines showed resistance reaction at seedling and moderate to susceptible at adult plant stage. Eight lines had resistance reaction and moderate reaction at seedling and adult plant stage, respectively. The lines M-88-3, M-88-6, M-88-14, M-88-16, M-89-8, M-89-10 and M-89-11 had the susceptible reaction at seedling tests and moderately resistant to moderately susceptible reaction at adult plant stage. These lines which had low values of slow rusting at adult plant stage could have durable resistance [21] This kind of resistance can be kept for a long time, even if pathogen

changes its genotype. Because durable resistance, such as slow rusting and high-temperature adult plant resistance (HTAP), is controlled by more than one genes (at least 2-3). [7].
Researchers should take into account durable resistance because the rust pathogens can easily change their genotypes by mutation, migration and selection effect of resistant cultivars on pathogens [10]. Therefore in following investigations, researchers should not emphasize only on race–specific resistance.

Table 2. Adult plant infection type, seedling reaction, coefficient of infection and final rust severity in promising wheat lines to yellow rust, in Ardabil

Lines	Seedling reaction[a]	Adult plant reaction[b]	Final rust severity	Coefficient of infection
M-88-1	0	MR	20	5
M-88-2	7	MS	40	30
M-88-3	**7**	**M**	**40**	**20**
M-88-4	5C	M	40	20
M-88-5	7	MS	50	37.5
M-88-6	**7**	**M**	**40**	**20**
M-88-7	2CN	M	60	30
M-88-8	7	MS	40	30
M-88-9	7	MS	40	30
M-88-10	7	MS	40	30
M-88-11	5C	MR	30	7.5
M-88-12	7	MS	50	37.5
M-88-13	8	MS	50	37.5
M-88-14	**8**	**M**	**40**	**20**
M-88-15	0	MR	30	7.5
M-88-16	**8**	**M**	**40**	**20**
M-88-17	0	M	20	10
M-88-18	2CN	S	100	100
M-89-1	0	M	20	10
M-89-2	8	MS	50	37.5
M-89-3	8	MS	40	30
M-89-4	2CN	MS	60	45
M-89-5	8	MSS	60	52.2
M-89-6	8	MS	40	30
M-89-7	8	MS	20	15
M-89-8	**8**	**MR**	**20**	**5**
M-89-9	4CN	M	30	15
M-89-10	**8**	**MR**	**30**	**7.5**
M-89-11	**8**	**MR**	**30**	**7.5**
M-89-12	8	MS	50	37.5
M-89-13	2CN	MS	40	30
M-89-14	7	MSS	40	34.8
M-89-15	4C	M	30	15
M-89-16	8	MS	30	22.5
M-89-17	8	MS	30	22.5
M-89-18	8	MS	40	30
Morocco	8	S	100	100

a: Letters C and N were used to indicate more than normal chlorosis and necrosis, respectively.
b: Infection types based on Roelfs et al. [18] ; MR= moderately resistant; small pustules surrounded by necrotic areas. MS= moderately susceptible; medium-sized pustules, no necrosis, but some chlorosis possible. MSS= moderately susceptible to susceptible; medium to large sized pustules without chlorosis or necrosis. S= susceptible; large pustules, no necrosis or chlorosis

Results of field assessment

The data on disease severity and host reaction was combined to calculate coefficient of infection (CI). According to Ali et al [3], lines with CI values of 0-20, 21-40, 41-60 were regarded as possessing high, moderate and low levels of adult plant resistance respectively. Table 2 clearly shows that disease pressure was considerably high as indicated by CI of susceptible check. Maximum CI recorded among tested lines was 45-100% of susceptible check for three entries (i.e. M-89-4, M-89-5 and M-88-18), while the remaining 33 were up to 37.5% of Morocco. Regarding to these results, common pathotypes of Ardabil were considered virulent on most evaluated lines (see Table 2). According to results of other researchers [2, 11] lines which had resistance reaction at both stage may probably carry major gene or combination of major genes based resistance, effective against all virulences used. However, the lines/ cultivars with race-

specific resistance often become susceptible within a few years after their release because of the rapid evolution of new virulent races of the pathogens [23].

Data on final rust severity of 36 lines along with susceptible check (Morocco) are shown in Table 2. A considering high disease pressure was recorded at the testing site as maximum FRS up to 100% was to recorded for Morocco and M-88-18, followed by M-89-5 and M-89-4 (60%), designed as moderately susceptible to susceptible, while none of the tested lines was recorded to be immune. Similarly based on FRS the tested lines were grouped in to three groups of partial resistance, *i. e*., high, moderate, low levels of partial resistance having 1-30%, 31-50%, 51-70% FRS respectively. Thirteen Lines were included in first group, and 19 lines were marked as having moderate level of partial resistance. Lines M-88-7, M-89-4 and M-89-5 were marked as having low level slow rusting. Similarly Broers et al [5] and Ali et al [3] and Safavi et al [19] also carried out field assessment of quantitative resistance to yellow rust for ranking of lines. According to the resistance level based on disease severity along with other slow rusting parameters, they found that resistance level ranged from very low to very high among the tested lines.

CONCLUSION

The results of current study showed that the lines had diversity regarding resistance reaction, ranging from moderate resistance to susceptible lines. Most of the evaluated lines exhibited moderate or good performance under high disease pressure shown by susceptible Check. Resistance of all categories of partial resistance to yellow rust were observed. The lines M-88-3, M-88-6, M-88-14, M-88-16, M-89-8, M-89-10 and M-89-11 supposed to be having genes for varying degrees of slow rusting or high temperature adult plant resistance (HTAP) can be used for future manipulation in wheat improvement program after confirmatory studies. Now day's marker-assisted selection is being applied to become task easier. Some of these markers have good association with HTAP and Slow rusting genes and can be used in selection and confirmation studies.

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