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Sources Of Seedling And Adult Plant Resistance In Advanced Wheat Lines To *Puccinia Striiformis* F. Sp. *Tritici*

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Safar Ali Safavi: Sources Of Seedling And Adult Plant Resistance In Advanced Wheat Lines To *Puccinia Striiformis* F. Sp. *Tritici*

ABSTRACT

Forty advanced 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 twice 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 AM-89-8, AM-89-10, AM-89-14, AM-89-15, AM-89-35, AM -89-36, AM-89-38 and AM-89-39 were susceptible at the seedling stage and had low level infection at adult plant stage. Consequently these lines with low values of FRS and CI at adult plant stage most probably have durable resistance. The lines AM-89-18, AM-89-19, AM-89-20, AM-89-28 and AM-89-31 with resistance reaction at seedling and adult plant stage may probably carry major genes or combinations of major genes.

Key words: wheat, seedling resistance, adult plant resistance, *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 [27]. Strip rust severely damages wheat production worldwide [13, 20] 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 [29]. 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 [14]. 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 [23]. 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 [17] 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 [13]. 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

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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, 18].

In this study we screened wheat genotypes against stripe rust under field conditions as well as in greenhouse. The objective of this study was to observe and evaluate the behavior of advanced wheat genotypes for various types of resistance against yellow rust, which can be selected or incorporated in commercial bread wheat for sustainable wheat yield.

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:

Forty advanced lines (Table1) with susceptible cultivar (Bolani) 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* [15] 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 twice after the sun set 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). Percent severity was recorded when Bolani reached maximum severity based on modified Cobb's scale [19] and reaction based on Roelfs *et al* [20]. 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=0.2, MR=0.4, M=0.6, MS=0.8, S=1 [28].

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 following.

Results of seedling reaction:

The results of seedling assessment estimated are listed in Table 2. Sixteen lines had resistance reaction and 20 lines had susceptible reaction at seedling stage. Four lines; AM-89-4, AM-89-5, AM-89-9 and AM-89-11 showed mixed reaction (resistance and susceptible at seedling stage).The lines AM-89-8, AM-89-10, AM-89-14, AM-89-15, AM-89-35, AM - 89-36, AM-89-38 and AM-89-39 had the susceptible reaction at seedling tests and moderately resistant to moderate reaction at adult plant stage. These lines which had low values of slow rusting at adult plant stage could have durable resistance [27]. 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.

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 40% of susceptible check for three entries (i.e. AM-9-25, AM-89-26 and AM-89-40), while the remaining 37 were up to 32% of Bolani. According to results of other researchers [2, 11] lines; AM-89-18, AM-89-19, AM-89-20, AM-89-28 and AM-89-31 which had resistance reaction at both stages 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 [30].

Data on final rust severity of 40 lines along with susceptible check (Bolani) have been shown in Table 2. A considering high disease pressure was recorded at the testing site as maximum FRS up to 100% was to record for Bolani, followed by AM-9-25, AM-89-26 and AM-89-40 (50%), designed as moderately susceptible. 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. Apart from five lines with all-stage resistance (AM-89-18, AM-89-19, AM-89-20, AM-89-28 and AM-89-31), 18 lines were included in first group, and 17 lines were marked as having moderate level of partial resistance. However, none of lines were marked as having low level slow rusting. Similarly Broers *et al* [5] and Ali *et al* [3] and Safavi *et al* [21] 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.

The lines AM-89-10, AM-89-11, AM-89-13, AM-89-14 and AM-89-23 with having cultivar Anza in pedigree (Table 1), and low values of coefficient of infection and final rust severity should be considered for further studies and breeding programmes. The cultivar Anza has *Yr18* conferring slow rusting to yellow rust and has linkage with *Lr34* that confers slow rusting to leaf rust [25]. The gene *Yr18* is also associated with resistance to spot blotch disease of wheat caused by *Bipolaris sorokiniana* [12] and the gene *Bdv1* that confers slow yellowing to barley yellow dwarf virus [26].

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

No.	Lines	Pedigree/Parents
1	AM-89-1	Parsi
2	AM-89-2	Sivand
3	AM-89-3	Pishtaz/3/Snb"s"//Emu"s"/Tjb84-1543
4	AM-89-4	Pishtaz//Lov24/Coc 75
5	AM-89-5	Pishtaz//Lov24/Coc 75
6	AM-89-6	Pishtaz/3/Jup/Bjy"s"//Kauz"s"
7	AM-89-7	Pishtaz//Falat/Barakat
8	AM-89-8	Bow"s"/Vee"s"//1-60-3/3/Cocoraque 75/4/Chamran
9	AM-89-9	Bow"s"/Vee"s"//1-60-3/3/MV 17/4/Pishtaz
10	AM-89-10	Gds/4/Anza/3/Pi/Nar//Hys/5/Bloudan/3/Bb/7C*2//Y50E/3*Kal/6/Pishtaz
11	AM-89-11	1-65-55/5/Pewee"s"/Azd/4/Anza/3/Pi/Nar//Hys/6/Cocoraque 75/7/Pishtaz
12	AM-89-12	Falat/Barakat/5/Omid/4/Bb/Kal//Ald/3/Y50E/3*Kal/Emu
13	AM-89-13	Anza/3/Pi/Nar//Hys/4/Alborz/5/1-66-75/6/Alvand//Aldan "s"/Ias 58
14	AM-89-14	Anza/3/Pi/Nar//Hys/4/Alborz/5/1-66-75/6/Alvand//Aldan "s"/Ias 58
15	AM-89-15	4771//Fkn/Gb/3/Vee "s"/Vee "s"/4/Buc "s"/5/1-66-44/6/Nanjing 8343/Kauz
16	AM-89-16	IR/FR (Eudiele)
17	AM-89-17	IR/FR (Aldric)
18	AM-89-18	IR/FR (FD01104-2)
19	AM-89-19	IR/FR (FD03142)
20	AM-89-20	PFAU/MILAN//FISCAL
21	AM-89-21	-
22	AM-89-22	-
23	AM-89-23	Anza/3/Pi/Nar//Hys/4/Alborz/5/1-66-75/6/Mat/2*Skauz
24	AM-89-24	Akbarabady/3/P106.19//Soty/Jt*3
25	AM-89-25	Akbarabady/3/P106.19//Soty/Jt*3
26	AM-89-26	(Omid//H7/4/4P839/3/Omid/Tdo/4/ICW HA81-1473)/5/Mirtos
27	AM-89-27	Gv/Ald "s"/5/Ald "s"/4/Bb/Gll/Cno..../6/Marv
28	AM-89-28	Gv/Ald "s"/5/Ald "s"/4/Bb/Gll/Cno..../6/Marv
29	AM-89-29	NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR
30	AM-89-30	WAXWING*2/4/SNI/TRAP#1/3/KAUZ*2/TRAP//KAUZ
31	AM-89-31	VORB/FISCAL
32	AM-89-32	PRL/2*PASTOR
33	AM-89-33	CHIR3/4/SIREN//ALTAR 84/AE.SQUARROSA (205)/3/3*BUC/5/PFAU/WEAVER
34	AM-89-34	SHARP/3/PRL/SARA//TSI/VEE#5/5/VEE/LIRA//BOW/3/BCN/4/KAUZ
35	AM-89-35	WAXWING*2/TUKURU
36	AM-89-36	WAXWING*2/TUKURU
37	AM-89-37	WBLL1*2/BRAMBLING
38	AM-89-38	WBLL1*2/BRAMBLING
39	AM-89-39	CNDO/R143//ENTE/MEXI_2/3/AEGILOPS SQUARROSA (TAUS)/4/WEAVER/5/2*PASTOR/6/SKAUZ/PARUS//PARUS
40	AM-89-40	WHEAR//2*PRL/2*PASTOR
41	Bolani	-

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

Lines	Seedling reaction[a]	Adult plant reaction[b]	Final rust severity	Coefficient of infection
AM-89-1	0	MR	20	8
AM-89-2	8	MS	40	32
AM-89-3	8	M	50	30
AM-89-4	4P;2, 3P7	M	40	24
AM-89-5	4P;,4P7	M	30	18
AM-89-6	7	M	40	24
AM-89-7	7	M	40	24
AM-89-8	7	MR	10	4
AM-89-9	5P0, 5P7	M	40	24
AM-89-10	7	MR	30	12
AM-89-11	6P0, 2P7	M	30	18
AM-89-12	7	M	40	24
AM-89-13	7	M	40	24
AM-89-14	7	M	30	18
AM-89-15	7	MR	30	12
AM-89-16	0	MR	10	4
AM-89-17	;2	MR	10	4
AM-89-18	0;	R	1	0.2
AM-89-19	0;	R	1	0.2
AM-89-20	2CN	R	1	0.2
AM-89-21	0	MR	20	8
AM-89-22	8	M	40	24
AM-89-23	8	M	40	24
AM-89-24	2CN	M	50	30
AM-89-25	7	MS	50	40
AM-89-26	7	MS	50	40
AM-89-27	0;	MR	10	4
AM-89-28	0;	R	1	0.2
AM-89-29	0	MR	10	4
AM-89-30	7	M	50	30
AM-89-31	0	R	1	0.2
AM-89-32	0	M	20	12
AM-89-33	0	M	40	24
AM-89-34	0	MR	20	8
AM-89-35	8	MR	10	4
AM-89-36	7	MR	20	8
AM-89-37	0	M	40	24
AM-89-38	8	M	30	18
AM-89-39	8	MR	10	4
AM-89-40	8	MS	50	40
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*. [20] ; R= resistance; without sporulation. 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

In this study we used coefficient of infection (CI) and final rust severity (FRS) for evaluating of adult plant stage under field condition. According to the results of researchers on cereal-rust pathosystems [21, 22, 23] there are positive correlation between different slow rusting parameters i.e. rAUDPC, CI and FRS, therefore in this investigation we used CI and FRS. Previously Sandoval-Islas *et al* [22] found good correlation of rAUDPC with quantitative resistance components, *i.e*. latent period and infection frequency. Ochoa and Parlevliet [16] also found high correlation coefficient between rAUDPC and yield losses. Field selection of partial resistance trait preferably by low rAUDPC and terminal ratings along with CI, is feasible in situations, where greenhouse facilities are inadequate [24]. Since all disease parameters strongly and positively correlated in different studies it can be concluded that FRS and CI are the most appropriate parameters. Lines identified with partial resistance characteristics should be improved /developed further by accumulating 4-5 minor genes to achieve near-immunity prior to deployment as a control strategy in the region for controlling yellow rust.

Conclusion:

The results of current study showed that the lines had diversity regarding resistance reaction, ranging from complete resistance to moderately 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 was observed. The lines AM-89-8, AM-89-10, AM-89-14, AM-89-15, AM-89-35, AM -89-36, AM-89-38 and AM-89-39 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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