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Slow Rusting Resistance in 19 Promising Wheat Lines to Yellow Rust in Ardabil, Iran

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Abstract: Yellow rust caused by *Puccinia striiformis* f. sp. *tritici* is undoubtedly, the most important fungal disease of wheat especially in central and Western Asia that causes significant annual yield losses. Production and use of cultivars with durable resistance is the best controlling method. For this purpose, study on reaction of 19 promising lines to yellow rust was carried out in Ardabil in 2008-2009 cropping year. Assessment of adult plant reaction was conducted under field condition with artificial inoculation. Seedling test was also conducted in greenhouse. Slow rusting resistance at adult plant stage was assessed through the Infection Type (IT), Disease Severity (DS), Relative Area Under Disease Progress Curve (rAUDPC) and Coefficient of Infection (CI). Results of mean comparison of CI and rAUDPC indicated that the lines; C-87-1, C-87-2, C-87-3 and C-87-18 had the highest CI and rAUDPC. The lines C-87-6, C-87-8 and C-87-11 had the susceptible reaction at seedling test and were moderately resistant to moderately susceptible at adult plant stage. Consequently, these lines with low rAUDPC (15.2 to 27.8%) most probably could have slow rusting resistance. The lines C-87-4, C-87-5, C-87-13, C-87-14 and C-87-17 had not any infection or were at low level of infection, thus, they were selected as immune or resistant lines. The rest lines were moderately resistant to moderately susceptible. In this study, correlation analysis of different parameters also showed highly strong relationship of CI with rAUDPC and disease severity (R^2 = 0.91 and 0.98, respectively).

Key words: Wheat genotypes, yellow rust, slow rusting, resistance

INTRODUCTION

Stripe rust of wheat caused by *Puccinia striiformis* Westend. f, sp. *tritici* Eriks. and Henn., is one of the most widely destructive plant diseases in the world (Line, 2002). The disease is a micro cyclic rust disease causing important economic losses on some important members of Graminae family (Kavak, 2009). 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 (Morgounov *et al*., 2004). 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 and 1.0 million ton in 1993 and 1995, respectively (Torabi *et al*., 1995). 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 (Afzal *et al*., 2007). The rusts of cereal can be controlled by fungicides, but it is not always economical and environmentally appropriate to use fungicide. Use of resistant cultivars is the most economical and the preferred method of controlling the rusts (Chen and Line, 2002). Although, some resistant cultivars are deemed to be non-specific, changes in the pathogens races have caused the failure of many resistant cultivars to stripe rust, suggesting race specificity (Roelfs *et al*., 1992). Non-durability of resistance in cultivars has caused breeders to look for slow-rusting resistance in breeding programs (Wiese, 1991). Slow-rusting resistance that appears to be race -nonspecific and durable have been found in wheat and efforts to find cultivars with this type resistance have continued for the last several years (Lee and Shaner, 1985).

Slow-rusting wheat cultivars infected with *Puccinia striiformis* exhibit longer latent period, smaller and fewer uredinia and less spore production than susceptible cultivars (Parlevliet, 1988; Roelfs *et al*., 1992). The latent period is one of the most important components of slow-rusting resistance (Dehghani and Moghaddam, 2004). Analysis of variance in study of Dehghani and Moghaddam (2004) showed the importance of both additive and dominance effects in controlling the latent period. In several cereals-rust pathosystems, the quantitative aspects of cultivar resistance have been described by means of the disease severity at a certain moment or plant development stage, the Area Under Disease Progress Curve (AUDPC) or by means of the

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apparent infection rate (r) (Broers *et al*., 1996). Sandoval-Islas *et al.* (2007) showed that quantitative resistance components have association with one another. The Latent Period (LP) and Infection Frequency (IF) were well correlated with the AUDPC (r = 0.7-0.8).

Several researchers have reported rust resistance in different wheat genotypes in Iran (Torabi *et al*., 1995). However, their studies were based only on vertical resistance. Little research has been reported on screening of wheat lines for slow rusting. The present study was therefore, designed to evaluate wheat lines for slow rusting. The study reports the findings of an investigation which was carried out to assess the slow rusting of 19 promising wheat lines.

MATERIALS AND METHODS

Seedling tests: Nineteen promising lines with susceptible cultivar (Morocco) that obtained from Cereal Department of Seed and Plant Improvement Institute, Karaj, Iran, were used in this study in 2008. 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 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 McIntosh *et al.* (1995) by scales 0-4; 0 = no visible uredia, 1 = small uredia with necrosis, 2 = small to medium sized uredia with green islands and surrounded by necrosis or chlorosis, 3 = medium sized uredia with or without chlorosis and 4 = large uredia without chlorosis. Infection Types (ITs) of 3+ or higher were regarded as susceptible, whereas ITs of 3 or lower were regarded as resistant. This experiment was repeated twice.

Field tests: This experiment was conducted in Ardabil Agricultural Research Station in 2008-2009. Each entry was planted in two rows of 1 m spaced at 30 cm. Plots were spaced at 65 cm. Experimental design was randomized complete block design with three replications. Artificial inoculation was carried out with Ardabil races 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 four times, starting when Morocco reached 30% severity according to the modified Cobb scale (Peterson, 1948) and reaction based on Roelfs *et al.* (1992). Coefficient of Infection (CI) which are calculated by combination of Disease Severity (DS) and Infection Type (IT), was used for estimating of Area Under Disease Progress Curve (AUDPC) after converting by formula; $\sqrt{CI+0.5}$. Constant values for infection types were used based on (immune = 0, R = 0.2, MR = 0.4, M = 0.6, MS = 0.8, S = 1; Stubbs *et al*., 1986). Estimation of AUDPC and rAUDPC was performed as follows (Milus and Line, 1986):

$$AUDPC = \frac{N_1(X_1+X_2)}{2} + \frac{N_2(X_2+X_3)}{2} + \frac{N_3(X_3+X_4)}{2}$$

where, X_1, X_2 and X_3, X_4 are the rust intensities recorded on the first, second, third and fourth recording dates. N_1 is interval day between X_1, X_2 and N_2 is interval day between X_2, X_3 and N_3 is interval day between X_3 and X_4:

$$rAUDPC = \frac{\text{line AUDPC}}{\text{susceptible AUDPC}} \times 100$$

Then, the data was statistically computed by MSTAT-C program as well as by using MS-Excel program for correlation analysis. Finally, resistance reaction at seedling and adult plant stages was compared for grouping of them.

RESULTS AND DISCUSSION

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

Seedling reaction: The results of seedling assessment estimated are shown in Table 1. Seven lines had susceptible reaction at seedling stage, 12 lines had resistant reaction. The lines C-87-6, C-87-8 and C-87-11 had the susceptible reaction at seedling tests and moderately resistant to moderately susceptible reaction at adult plant stage. These lines which had low rAUDPC (15.2 to 27.8%) at adult plant stage could have durable resistance (Sandoval-Islas *et al*., 1998). This kind of resistance can be kept for along 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) (Dehghani and Moghaddam, 2004).

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 (Hovmøller,

Table 1: Adult plant infection type, seedling reaction and mean comparison for coefficient of infection, AUDPC and rAUDPC in promising wheat lines to yellow rust

		Mean comparison based on Duncan multiple testing*			
Lines	Adult plant reaction	Mean of coefficient of infection	Mean of AUDPC	Mean of rAUDPC	Seedling reaction**
C-87-1	MS-S	69b	164.8b	66b	3+
C-87-2	MS	46.7c	158.4b	63.4b	3+
C-87-3	MS-S	69b	146.1b	58.5b	3+
C-87-4	I-R	1e	25e	10e	0
C-87-5	I-R	1e	29.1e	11.6e	0
C-87-6	MR-MS	15de	38de	15.2de	3+
C-87-7	MR-MS	6e	46.6cde	17.1cde	Fleck 1 CN
C-87-8	MR-MS	10.7e	66.7cd	26.7cd	3+
C-87-9	MR	13.3e	63.2cd	25.4cd	Fleck 1 CN
C-87-10	MR-MS	3.3e	32.3e	12.9e	0
C-87-11	MR-MS	7.3e	69.4c	27.8c	3+
C-87-12	R-MR	2e	27.3e	10.9e	0
C-87-13	R	1e	28.1e	11.2e	Fleck 1 CN
C-87-14	R	1e	28.1e	11.2e	Fleck 1 CN
C-87-15	R-MR	3.3e	30.1e	12.1e	0
C-87-16	MR-MS	6.7e	50.7cde	20.3cde	Fleck 1 CN
C-87-17	R	1e	29.5e	11.8e	0
C-87-18	MS	27.3d	136.2b	54.5b	3+
C-87-19	MR	11.3e	71.4c	28.6c	0
Morocco	S	100a	249.7a	100a	3+

*Means followed by the same letters in each column are not statistically significant at 1% level. **Infection type based on McIntosh *et al.* (1995); 0, 1, 2 are resistant and 3^+ is susceptible; Minus and plus signs were used to indicate variation in ITs and letters C and N were used to indicate more than normal chlorosis and necrosis, respectively

2001; Ben Yehuda *et al.*, 2004). Therefore, in following investigations, researchers should not emphasize only on race-specific resistance.

CI value: The data on disease severity and host reaction was combined to calculate Coefficient of Infection (CI). According to Ali *et al.* (2009), lines with CI values of 0-20, 21-40 and 41-60 were regarded as possessing high, moderate and low levels of adult plant resistance, respectively. Table 1 clearly shows that disease pressure was considerably high as indicated by CI of susceptible check. Maximum CI recorded among tested lines was 46-69% of susceptible check for three entries (i.e., C-87-1, C-87-2, C-87-3), while the remaining 16 were up to 30% of Morocco. Regarding to these results, common pathotypes of Ardabil were considered virulent on some evaluated lines (Table 1). According to results of other researchers (Ali *et al.*, 2007; Johnson, 1988), lines C-87-4, C-87-5, C-87-13, C-87-14 and C-87-17 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 (Chen *et al.*, 1993). Therefore, the lines C-87-4, C-87-5, C-87-13, C-87-14 and C-87-17 need further inheritance studies or marker-assisted identification for identifying of their resistance.

rAUDPC value: Based on the rAUDPC values, promising lines were categorized into 2 distinct groups according to Ali *et al.* (2007). The first group included genotypes exhibiting rAUDPC values up to 30% of check, while lines showing rAUDPC values up to 70% of check were placed in second group. In these lines, rust initiated and sporulated but with final chlorotic and necrotic strips (MR and/or MS infection types). Subsequently, the progress of rust development remained slower and restricted. Lines of group 1 were marked as better slow rusting and that of group 2 were marked as moderately slow rusting since, they also developed epiphytotic of very low potential as indicated by their rAUDPC values despite the ultimate expression of high infection type. Lines with such traits are expected to possess genes that confer partial resistance (Parlevliet, 1988). C-87-6, C-87-7, C-87-8, C-87-9, C-87-10, C-87-11, C-87-12, C-87-15, C-87-16 and C-87-19 exhibited rAUDPC values less than 30% of Morocco and were marked as better slow rusting. The lines having rAUDPC values up to 70% of susceptible check were grouped as moderately slow rusting in group 2. These were C-87-1, C-87-2, C-87-3 and C-87-18. Both, group 1 and 2 comprised lines with varying degrees of partial resistance which has been advocated to be more durable (Singh *et al.*, 2004). Moreover, lines with acceptable levels of slow rusting restrict the evolution of new virulent races of the pathogen because multiple point mutations are extremely rare in nature (Ali *et al.*, 2007). None of the tested line was marked as susceptible or highly susceptible.

Association between slow rusting parameters: Field assessment of slow rusting resistance was evaluated through final disease severity, rAUDPC and coefficient of infection. CI is the mostly used parameter for the purpose (Ali *et al.*, 2008). During in this study, an attempt was made to elucidate the relationship between these parameters. Positive relation of coefficient of infection was found with final disease severity and rAUDPC with a strong R^2 value that was 98 and 91%, respectively (Fig. 1a, b). These results were agreed with the results of other researchers (Ali *et al.*, 2008; Sandoval-Islas *et al.*, 2007). Regarding to good relation of AUDPC with quantitative resistance components, i.e., latent period and infection frequency (Sandoval-Islas *et al.*, 2007), we can use rAUDPC or CI for measuring slow rusting or partial resistance.

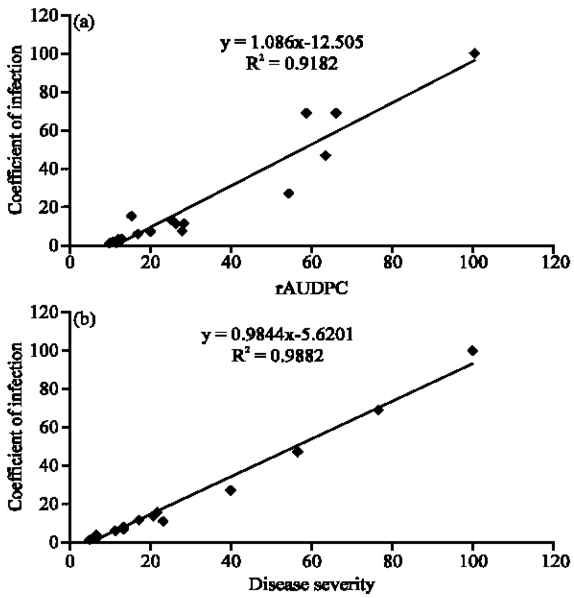

Fig. 1: (a) Association between rAUDPC and coefficient of infection for assessment of slow rusting and (b) association between final disease severity and coefficient of infection for assessment of slow rusting

CONCLUSION

The results of current study showed that the lines had diversity regarding resistance reaction, ranging from immunity to partially resistant lines. Most of the evaluated lines exhibited better performance under high disease pressure shown by susceptible check. Resistance of all categories including immune to partial resistance to yellow rust were observed. These lines (especially C-87-6, C-87-8 and C-87-11) were supposed to be having genes for varying degrees of slow rusting can be used for future manipulation in wheat improvement program after confirmatory studies. However, these lines should be assessed over years and locations for yellow rust along with other desirable characters before approval.

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