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Assessment of Wheat Breeding Lines for Slow Yellow Rusting (*Puccinia striiformis* West. Tritici)

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Abstract: A preliminary infection experiment was carried out during 2005-06 to identify slow yellow rusting sources of resistance in 20 NIA-wheat breeding lines along with Morocco as susceptible check at Nuclear Institute for Food and Agriculture, Peshawar. It was revealed that the current pathotypes of *Puccinia striiformis* West. *tritici* (*Pst*) were found virulent on all tested genotypes except NIA-6 and NIA-14. Host-pathogen compatibility in remaining lines facilitated the assessment of slow rusting trait and it was assessed through the epidemiological parameters viz., Final Rust Severity (FRS), Area Under Rust Progress Curve (AURPC) and Infection Rate (IR). Maximum FRS of 70% was rated in five lines while in the remaining 13 lines it ranged between 10 to 60%. Relative AURPC values up to 30% of the susceptible check were recorded for 10 lines while up to 70% for eight lines, showing desirable and good slow rusting behavior, respectively. Relative infection rate values ranged from 0 for NIA-7 to 1100-1300, recorded for eight lines. NIA-7 has a constant severity of 10% over assessment dates with lower AURPC value and was considered as better slow rusting line. Among various epidemiological parameters used for assessment of slow rusting trait, AURC was found to be a reliable parameter. Infection rate, on the other hand did not reveal the actual slow rusting behavior of the tested lines. Based on slow rusting trait, the tested lines may probably have genes for varying degrees of slow yellow rusting and can be used for further manipulation in wheat improvement program after confirmatory studies.

Key words: Wheat genotypes, stripe rust, slow rusting, durable resistance

INTRODUCTION

Food security and self-sufficiency are not achievable without enhancing wheat production in Pakistan. Non-availability of improved varieties with durable disease resistance is one of the major reasons for various epidemics and low wheat production in the country. Severe losses due to different wheat diseases, including stripe rust have been reported both in past and recently (Saari *et al*., 1995; Kisana *et al*., 2003). Stripe rust or yellow rust of wheat, caused by *Puccinia striiformis* Westend f. sp. *Tritici*, is among the most important foliar diseases of wheat and its regular outbreaks in the country have caused serious losses to national economy (Roelf and Bushnell, 1985; Saari *et al*., 1995; Kisana *et al*., 2003). The only economic and practical control of rust diseases can be achieved through genetic resistance (Singh *et al*., 2004).

Rust resistance in improved wheat cultivars in the past was solely based on major genes that often were overcome by virulent pathogenic mutant strains within five to seven years (CIMMYT, 1992). This was the case for Yr9 based cultivars, Pirsabak-85 and Pak-81, when these became susceptible during 1994-95 and resulted in yield losses up to 40% (Saari *et al*., 1995). Similarly, the resistance of Inqilab-Inqilab-91, based on Yr27, was broken down and was severely infected by yellow rust (Kisana *et al*., 2003) causing severe losses. Such major gene(s)-based resistance are lost very rapidly due to evolution of virulence by the pathogen to these genes. The alternative is to search for partial resistance based on minor genes, which impart durability. The ability of certain genotypes to retard rust development is a form of partial resistance and is referred to as slow rusting or durable resistance (Singh *et al*., 2004; Clifford, 1972).

Several researchers have reported rust resistance in different wheat breeding lines of Pakistan (Mirza *et al*., 2000). However, their studies were based solely on vertical resistance. Little research has been reported on screening of wheat germplasm for slow rusting. The present study was thus designed to assess wheat breeding lines for slow rusting. The study reports the

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preliminary findings of a study which was carried out to evaluate the slow yellow rusting performance of 20 wheat breeding lines.

MATERIALS AND METHODS

Seed source and field sowing: The study was conducted at Nuclear Institute for Food and Agriculture (NIFA), Peshawar. Seeds of 20 breeding lines were received by NIFA under a coordinated program from Nuclear Institute for Agriculture (NIA) Tandojam, Sindh, Pakistan. Each entry was separately planted in strips of small adjacent plots with 2 rows plot^{-1} of 2.5 m length separated by 0.3 m with a distance of 0.6 m between entries. Morocco, a super susceptible wheat cultivar, was sown around entries as spreader and also to serve as an adult plant susceptible check.

Inoculum source and inoculation: Rust inoculum was obtained from Crop Diseases Research Program (CDRP) of National Agricultural Research Center (NARC), Islamabad which carried virulence for yellow rust resistance genes Yr1, Yr6, Yr7, Yr8, Yr9, Yr17, Yr18 and Yr27. Artificial inoculation was carried out with this Pakistani Yr inoculum by spraying all test entries and spreader rows with urediniospores suspended in double distilled (having 2-3 drops of non-phytotoxic wetting agent) with 300 mg of spores per liter of water, 2-3 times after the sun set as described by (Roelfs *et al*., 1992).

Estimation of disease severity and of slow rusting parameters: Data were scored four times at seven days interval, starting when Morocco reached 50% severity according to the Modified Cobb Scale (Paterson *et al*., 1948). The Area under Disease Progress Curve (AURPC) was estimated by using the formula adopted by Pandey *et al*. (1989). Relative AURPC was worked out by comparing AURPC value of each entry with Morocco. Infection rate r, the unit leaf area damaged by disease per day was estimated for the whole epidemic period after the time when Morocco showed >50% severity, following Vanderplank (1968). Relative infection rate was worked out for each entry by comparing r value with susceptible check.

Grain yield and 1000-kernel weight: Grain yield was calculated for each entry by harvesting entire two rows and weighing their grains through electronic balance. Kernel weight was taken for 500 kernels, which was converted to 1000-kernel weight.

RESULTS AND DISCUSSION

Parameters used as criteria to identify slow yellow rusting genotypes under field conditions included pattern of disease increase, relative final disease severity, relative AURPC and relative infection rate. Results regarding these parameters are described as under:

Pattern of virulence and disease increase: Results regarding Yr virulence pattern and disease increase over time are presented in Fig. 1, which clearly shows that disease pressure was considerably high as indicated by the severity of susceptible check. Yr pathotypes were considered virulent on all tested lines except NIA-6 and NIA-14. These two lines may probably carry major gene or combination of major genes based resistance, effective against all virulences used. These lines need further inheritance studies or marker assisted identification for exploring basis of their resistance displayed in the current study. Susceptible check Morocco showed almost linear pattern of increase in disease severity over time, between initial and final disease scoring. NIA-2 and NIA-5 exhibited severity after second scoring. Most of the lines, including NIA-2, NIA-17 and NIA-18 were having more increase in severity during first and second scoring. NIA-1, NIA-3, NIA-8, NIA-12 and NIA-17 attained 70% severity after 144 days. However, NIA-1, NIA-3 and NIA-

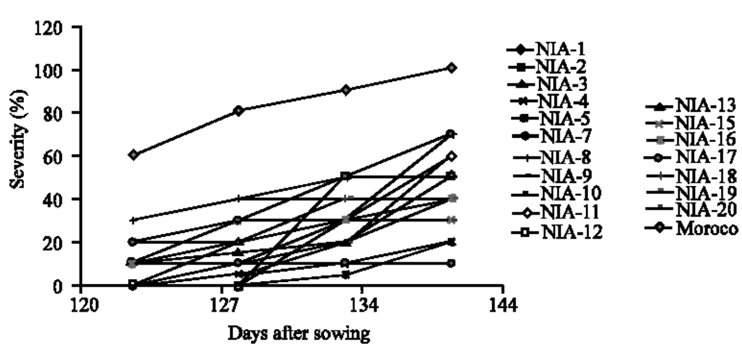

Fig. 1: Pattern of virulence and disease increase over time for 20 NIA-breeding lines at NIFA, during 2005-06

12 reached to only 30% severity at 134 days after sowing, while NIA-8 and NIA-17 showed 50% severity at 134 days after scoring. Increase in disease severity was slower in NIA-4 and NIA-5 which reached to only 20% severity. Similarly NIA-7, being highly resistant, showed a constant severity of 10%. Previously, other researchers have also reported variation among different advanced and candidate breeding lines of Pakistan for stripe rust resistance (Shah *et al*., 2003; Mirza *et al*., 2000).

Final disease severity: Maximum relative final disease severity recorded among the tested lines were 70% of the susceptible check for five entries (i.e., NIA-1, NIA-3, NIA-8, NIA-12 and NIA-17), while the remaining 13 were between 10 to 60% of Morocco. NIA-4, NIA-5, NIA-15 and NIA-20 exhibited disease severity up to 30% of the susceptible check and were regarded as better slow rusting. NIA-1, NIA-2, NIA-3, NIA-8, NIA-9, NIA-10, NIA-11, NIA-12, NIA-13, NIA-16, NIA-17, NIA-18 and NIA-19, displayed relative final disease severity up to 70% of susceptible check and were marked as moderately slow rusting (Fig. 2). This final disease severity is assumed to represent the cumulative result of all resistance factors during the progress of epidemic (Parlevliet and van Omeren, 1975). Previously, Broers *et al.* (1996) also carried out field assessment of quantitative resistance to yellow rust for ranking of wheat breeding lines. According to the resistance level based on Disease Severity (DS) along with other slow rusting parameters, they found that resistance levels ranged from very low (in Taichung 23) to very high (in Parula) among the tested wheat breeding lines.

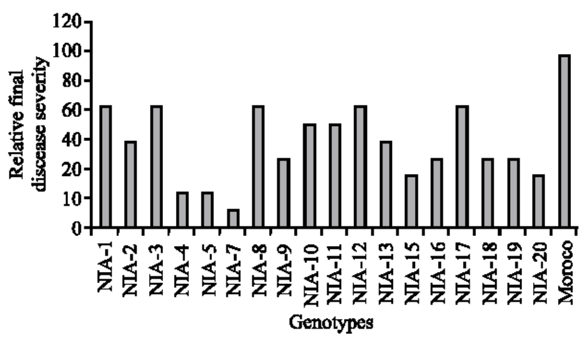

Fig. 2: Relative yellow rust severity for NIA-wheat breeding lines along with susceptible check, at NIFA, during 2005-06

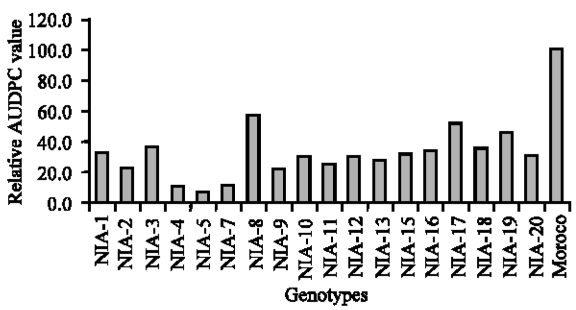

Fig. 3: Relative AURPC estimation of Yr for NIA-wheat breeding lines along with susceptible check, at NIFA, during 2005-06

AURPC value: Based on the AURPC values, breeding lines were categorized into two distinct groups. The first group comprised genotypes exhibiting relative AURPC values up to 30% of check, while lines showing AURPC 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 AURPC values despite the ultimate expression of high infection type (Fig. 3). Breeding lines with such traits are expected to possess genes that confer partial resistance (Parlevliet, 1988). NIA-2, NIA-4, NIA-5, NIA-7, NIA-9, NIA-10, NIA-11, NIA-12, NIA-13 and NIA-20 exhibited relative AURPC values less than 30% of Morocco and were marked as better slow rusting. Lines having relative AURPC values up to 70% of susceptible check were grouped as moderately slow rusting in group 2. These were NIA-1, NIA-3, NIA-8, NIA-15, NIA-16, NIA-17, NIA-18 and NIA-19. Both group 1 and 2 included lines with varying degrees of partial resistance which has been advocated to be more durable (Singh *et al*., 2004). Furthermore, 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 (Schafer and Roelfs, 1985). None of the tested line was marked as susceptible or highly susceptible and may be advanced further.

Infection rate: Relative infection rate (r) ranged from 0 for NIA-7 to 1350 for NIA-1, NIA-3, NIA-10, NIA-11 and NIA-12 (Fig. 4). NIA-7 showed a constant disease severity, thus showing no increase per unit time with r value of 0. The infection rate assumed for susceptible check Morocco as 100. The apparent infection rate of certain lines was more than Morocco due to the fact that disease scoring was started when disease severity was >50% on Morocco. Therefore the actual infection rate for Morocco may even be more. Slow rusting behavior was assessed through comparison of relative infection rate. Those

Table 1: Slow rusting parameters along with 1000-kernel weight and grain yield of NIA-wheat breeding lines at NIFA, Peshawar, during 2005-06

Genotypes	Relative Disease severity	Relative AURPC value	Relative infection rate	1000-kernel weight (g)	Grain yield (kg)
NIA-1	70	33	1350	42	1.20
NIA-2	50	22	1300	42	0.60
NIA-3	70	37	1350	44	0.80
NIA-4	20	11	1100	43	0.60
NIA-5	20	7	1100	42	0.80
NIA-6	0	0	0	42	0.60
NIA-7	10	12	0	35	0.60
NIA-8	70	57	200	39	0.60
NIA-9	40	22	1250	39	0.60
NIA-10	60	31	1350	47	0.80
NIA-11	60	25	1350	49	1.00
NIA-12	70	30	1350	50	0.80
NIA-13	50	28	350	43	0.80
NIA-14	0	0	0	48	0.80
NIA-15	30	32	250	43	0.80
NIA-16	40	34	300	39	0.60
NIA-17	70	52	250	44	0.60
NIA-18	40	35	300	37	0.60
NIA-19	40	45	50	40	0.60
NIA-20	30	30	100	39	0.60
Morocco check	100	100	100	36	0.56

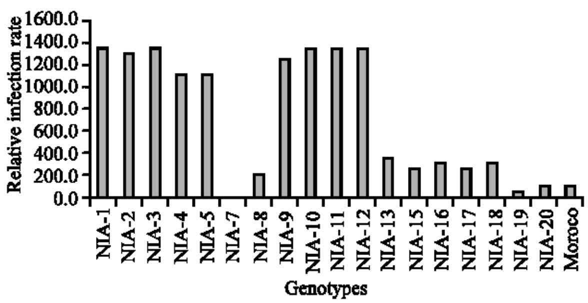

Fig. 4: Relative infection rate r of Yr for NIA-wheat breeding lines along with susceptible check, at NIFA, during 2005-06

having r value up to 100 were marked as better slow rusting. Those having r value ranging from 100 to 400 were marked as moderately slow rusting. The remaining lines were marked as poor slow rusting. NIA-19 and NIA-20 showed RIR value up to 100 and were marked as better slow rusting. NIA-8, NIA-13, NIA-15, NIA-16, NIA-17 and NIA-18 exhibited r value up to 350, marked as moderately slow rusting. NIA-1, NIA-3, NIA-10, NIA-11 and NIA-12 were having maximum r values (1350). NIA-2, NIA-4, NIA-5 and NIA-9 also showed higher value of r (1100 to 1300). These were found to be poor slow rusting lines based on their relative infection rate.

Present study demonstrated that the apparent infection rate r seemed to produce unreliable estimates of slow yellow rusting resistance when compared with disease severity and AURPC because it did not mark Morocco as the fast ruster. Moreover, more variation in r among the tested lines than the disease severity and AURPC, is partly because apparent infection rate is a regression coefficient with larger error variance. Similar results were found for stem rust and leaf rust of wheat (Broers, 1989; Rees *et al*., 1979). When the epidemic is studied from the very beginning, only then r might give accurate estimate of the level of resistance for cultivars/lines with low level of resistance assuming that the disease progress curve follows a logistic pattern which is not necessary for the case of yellow rust.

Relation of slow rusting parameters with yield parameters: Maximum 1000-kernel weight was produced by NIA-12 (50 g) followed by NIA-11 (49 g) and NIA-10 (47 g) which were having relative AURPC value of 30%, 25 and 31% of susceptible check, respectively (Table 1). However, all of the three were having maximum infection rate and higher final disease severity. Susceptible check having maximum relative disease severity and relative AURPC value produced kernels with least kernel weight (36 g) after NIA-7 (35 g). The minimum kernel weight of NIA-7 despite of its highly better slow rusting behavior may be due to its lower genetic potential and not due to rust infection. Slight negative correlation was observed between 1000-kernel weight and relative AURPC value.

Maximum grain yield per plot was produced by NIA-1 (1.2 kg) followed by NIA-11 (1.0 kg), having relative AURPC values of 33 and 25%, respectively. However, both of them were having higher relative disease severity and r values. Susceptible check i.e., Morocco having maximum relative disease severity and relative AURPC values, produced minimum grain yield (0.56 kg). NIA-1, NIA-5, NIA-10, NIA-13, NIA-14 and NIA-15, having relative AURPC values up to 40%, produced grain yield of 0.8 g. Several other researchers have also reported significant correlation between rust infection and grain yield losses (Allan *et al*., 1963). Because of negative correlation of relative AURPC of varying degree with 1000-kernel weight and grain yield, it is suggested that relative AURPC may preferably be used to monitor the influence of disease on grain yield as compared to other epidemiological parameters.

CONCLUSION AND RECOMMENDATIONS

The present study revealed that most of the tested lines displayed better performance under high disease pressure when compared with susceptible check. None of the lines was marked as susceptible or highly susceptible while showing resistance of all categories including immune to partial resistance to yellow rust. Among various slow rusting parameters, AURPC was found to be a reliable parameter during the present study. Based on slow rusting behavior, the tested lines were supposed to be having genes for varying degrees of slow yellow rusting and may be used for further genetic manipulations. The tested lines may be advanced further, if having better performance, otherwise. However, these lines should be tested over years and locations for yellow rust along with other desirable characters, before approval.

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