Identification of slow rusters in bread wheat genotypes

Rajesh Kumar Patidar[1], Ishwar Kenchappa Kalappanavar* and Srikant Kulkarni[2]

Dr Sanjaya Rajarama Wheat Laboratory
University of Agricultural Sciences, Dharwad-580 005

Abstract

Genotypes HD-2189, HW-2021 showed the typical characteristics of slow rusters. These genotypes recorded low ACI, low AUDPC, considerable more latent period, medium pustule size and density and less rate of infection with good quantity of yield per hectare. However, genotypes DWR-195, DWR-162 and MACS-2496 recorded maximum ACI and relevant adverse values compared to slow leaf rusting genotypes and identified as fast rusters.

Key words: Slow rusters, bread wheat, latent period, rate of infection and AUDPC

Introduction

Wheat is the second most important food crop of the India, which contributes nearly one-third of the total food grain production. Wheat has already been proved to be the best component under multiple cropping system of the state. The leaf rust being a long distance disseminating and obligate parasite shows a vast diversity in pathogencity. The pathogen shifted its virulence time to time and new pathotypes emerged in the nature which made the breeders to use vertical resistance genes. The growing of slow leaf rusters is very outstanding tactic to reduce the disease incidence as the slow leaf rusters are characterized by slow progress of the disease, which endows with very less terminal disease severity and also reduces the extent of losses. In the present study an attempt was made to identify the slow leaf rusting varieties of bread wheat based on various parameters of slow leaf rusting mechanism.

Material and methods

The experiment on slow leaf rusters was carried out during *rabi* 2005-06. Eighteen genotypes (Table 1) of bread wheat having diverse genetic resistance to leaf rust were sown in three replications in a plot size of 2.76 m2 (1m x 12 rows). Checks were planted all around the experimental plots using the universal susceptible varieties like Lal Bahadur, Agra Local, Gulab, N-59 and Local Red. At boot leaf stage of the crop (30 days after sowing (DAS)), a suspension of mixture of pathotypes of leaf rust was sprayed on the genotypes. Observations on the following parameters were recorded.

[1] Current Address: AICRP on Wheat, MARS, UAS, Dharwad, [2] Current Address : Professor and Head (Retd), Department of Plant Pathology, University of Agricultural Sciences, Dharwad-580 005.
*Corresponding author email: *ikkyashu@gmail.com*

Average coefficient of infection: Five plants were randomly selected in each plot and tagged. Disease severity of leaf rust was recorded. Then average coefficient of infection (ACI) was calculated by multiplying the per cent infection and response value, assigned to each infection type, as per Loegering scale (Joshi *et al*., 1988). The ACI for each variety was computed for five observations at an interval of ten days.

Latent period: To reflect the average time required for appearance of pustules, the latent period was calculated as sum of the percentage of visible infection sites (flecks) that developed into pustules daily (Kuhn *et al*., 1978).

Pustule size: The average length and breadth of pustule on the central two third of the leaf was estimated by using stereo binocular microscope at a magnification of 10X (calibrated) in µm at the end of cropping season (Ohm and Shaner., 1976).

Pustule density: Number of pustules per square centimeter of leaf area were estimated for basal, mid and top portions of each leaf as described by Peterson *et al.* (1948) and averaged at the end of cropping season.

Rate of infection ('r'): The apparent rate of infection ('r') at different intervals was calculated by using the formula given by Van der Plank (1968).

$$r = \frac{2.3}{t_2 - t_1} \log_{10} \frac{X_2}{X_1}$$

Where,

r = Apparent rate of growth of disease or rate of infection (units day-1)

X_1 = Per cent disease severity at t_1 date,

X_2 = Per cent disease severity at date t_2

Table 1. Leaf rust incidence and components of slow leaf rusting in bread wheat genotypes

Sl. No.	Genotype	Latent period (days)	Pustule size (µm)		Pustule density (cm2)	Average coefficient of infection (ACI)
			Length	Breadth		Mean*
1	DWR 195	9.67	63.25	14.56	16.77	79.78 (8.87)
2	GW 322	26.33	12.62	8.47	13.65	20.12 (4.45)
3	RAJ 4037	21.67	11.98	9.55	11.28	21.74 (4.61)
4	NIAW 34	28.67	20.43	7.31	12.35	19.26 (4.07)
5	MACS 2496	10.00	45.48	15.44	14.74	42.10 (6.40)
6	UP 2565	27.67	18.93	11.48	10.64	17.46 (4.14)
7	HD 2189	24.67	17.57	7.02	10.79	3.07 (1.97)
8	GW 344	14.00	27.42	4.07	12.83	20.76 (4.59)
9	GW 349	19.00	20.70	10.52	11.56	13.95 (3.78)
10	DWR 162	14.33	56.47	24.46	15.37	66.17 (8.02)
11	HD 2160	14.67	28.42	7.40	7.40	4.18 (2.13)
12	WL 1562	16.00	17.28	9.51	6.00	0.30 (1.14)
13	HW 2021	27.00	28.14	17.98	7.84	2.67 (1.88)
14	HW 2008	30.33	15.39	9.81	5.25	0.23 (1.10)
15	K. Mutant	14.33	31.25	10.70	5.70	0.29 (1.13)
16	HP 1633	32.67	19.30	10.61	4.81	0.37 (1.16)
17	DL 784-3	28.00	21.41	11.23	5.07	0.32 (1.14)
18	HW 2022	29.67	18.53	13.60	4.24	0.37 (1.17)
Mean		21.59	26.37	11.32	9.80	17.40 (3.43)
SEm±		0.93	0.57	0.39	0.35	
CD at 5%		2.69	1.63	1.27	1.00	

*Data in parenthesis are $\sqrt{x+1}$ -transformed values.

Area under disease progress curve (AUDPC): The "Area Under Disease Progress Curve" was calculated by using the formula suggested by Wilcoxson *et al.* (1975).

$$\text{AUDPC value} = \sum_{I=1}^{k} \tfrac{1}{2} (Si + Si\text{-}1) \times d$$

Where,

Si = Disease severity at the end of time I,

k = Number of evaluations of disease and,

d = Interval between two evaluations.

Yield assessment: Grain yield per plot was recorded and converted into q ha^{-1} and 1000 grain weight from each treatment was recorded.

All the data were analyzed statistically. The correlation coefficients were calculated between the slow leaf rusting parameters and per cent loss in grain yield as well as thousand grain weight.

Results and discussion

Average leaf rust coefficient of infection (ACI): DWR 195 showed maximum (38.02) value of ACI followed by DWR 162 (28.75) and MACS 2496 (16.08) after 50 DAS (Table 1). Minimum average coefficient of infection was discerned in HD 2160 (0.24). GW 322 (6.94) was on par with Raj 4037 (7.15). Similarly the HD 2189 (1.07) was on par with HW 2021 (1.04) and HD 2160 (0.24) was on par with WL 1562 (0.13). After 60 DAS, DWR 195 (71.57) recorded maximum ACI followed by DWR 162 (46.96) and MACS 2496 (29.03). These genotypes diverged significantly with each other (Table 1). HW 2008 (0.16) documented least disease severity at the second week of observation followed by WL 1562 (0.21) and Kharchia Mutant (0.22). Statistically, UP 2565 (9.83) was on par with NIAW 34 (9.25) and GW 349 (9.32).

After 70 DAS, at the third week of observation maximum ACI was recorded in DWR 195 (89.36) followed by DWR 162 (67.55) and MACS 2496 (43.27) which differ appreciably with each other (Table 1). Least ACI was observed in HD 2008 (0.22) followed by Kharchia Mutant (0.32) and WL 1562 (0.33) and DL 784-3 (0.33) with same value. NIAW 34 (16.37) was on par with UP 2565 (15.64) whereas GW 344 (21.89) was found on par with Raj 4037 (20.53). After 80 DAS, in the fourth week of observation DWR 195 continued to evidence maximum ACI of 99.93 followed by DWR 162 (88.49) and MACS 2496 (58.60), which were significantly different from each other and with other genotypes (Table 1). WL 1562 (0.39) recorded minimum ACI followed by Kharchia Mutant (0.41) and DL 784-3 (0.43) was statistically on par with each other. GW 322 (28.47) was on par with Raj 4037 (28.26) and NIAW 34 (28.43). Similarly, UP 2565 (24.78) was found at par with GW 344 (25.73). WL 1562 (0.39), HW 2008 (0.30), Kharchia Mutant (0.41), HP 1633 (0.54), DL 784-3 (0.43) and HW 2022 (0.54) showed similar fashion of resemblance as revealed in last three observations. After 90 DAS, at the fifth and final observation week the genotype DWR 195 sustained with the maximum ACI of 100.00 followed by the DWR 162 (99.12) and MACS 2496 (63.51). DL 784-3 (0.59), HP 1633 (0.70) and HW 2022 (0.59) continued to be at par with each other. The least ACI was evidenced in the WL 1562 (0.45) followed by HW 2008 (0.46) and Kharchia Mutant (0.52), which were on par with each other.

Components of slow leaf rusting mechanism: Latent period: The longest latent period was observed on HP 1633 followed by HW 2008 and HW 2022 having latent period values of 32.67, 30.33 and 29.67 days, respectively (Table 1). DWR 162 (14.33 days), HD 2160 (14.67 days), Kharchia Mutant (14.33 days) and WL 1562 (16.00 days) were on par with each other with respect to latent period.

Pustule size: The largest pustule length was recorded on DWR 195 (63.25 μm) followed by DWR 162 (56.47 μm) and MACS 2496 (49.48 μm) whereas, greatest pustule breadth was observed on DWR 162 (24.46 μm) followed by HW 2021 (17.98 μm) and MACS 2496 (16.44 μm) (Table 1). UP 2565 (18.93 μm), HD 2189 (17.57 μm), WL 1562 (17.28 μm) and HW 2022 (18.53 μm) were on par with each other.

Pustule density: Maximum number of pustules per square centimeter was recorded on DWR 195 (16.77 cm^{2-1}) followed by DWR 162 (15.37 cm^{2-1}) and MACS 2496 (14.74 cm^{2-1}) (Table 1). Minimum number of pustules per square centimeter was observed on HW 2022 (4.24 cm^{2-1}) followed by DL 784-3 (5.07 cm^{2-1}) and Kharchia Mutant (5.70 cm^{2-1}). DWR 195 (16.77) and DWR 162 (15.37 cm^{2-1}) were on par with each other.

Rate of disease development: The peak average 'r' value was observed on HD 2160 (0.132) followed by HD 2189, UP 2565 and Raj 4037 with 'r' values 0.061, 0.060 and 0.060, respectively. The least average 'r' value was noticed on HW 2022 (0.030) followed by Kharchia Mutant (0.031) and DL 784-3 (0.033) (Table 2).The 'r' value for each genotype showed a tendency of declining after each passing week. Nevertheless, here again there were exceptions in genotypes such as UP 2565, and HD 2189 wherein, the disease development was steady in between 47-54 DAS.

Area under disease progress curve: The AUDPC figures varied significantly, maximum AUDPC value was observed on the genotype DWR 195 (1802.55) followed by DWR 162 (1621.67) and MACS 2496 (1051.55) which, differed notably with each other. The lowest value of AUDPC was recorded on HW 2008 (31.42) followed by WL 1562 (36.42), Kharchia Mutant (39.41), DL 784-3 (42.77), HP 1633 (51.44), HD 2189 (102-44) and HW 2021 (171.23) (Table 2). Raj 4037 (703.44) was statistically on par with GW 322 (662.01). Similarly, GW 322 (662.01) was on par with GW 344. GW 344 (610.47) was on par with NIAW 34 (569.71) whereas UP 2565 (482.55) was on par with GW 349 (434.34) and WL 1562 (36.42). HW 2008 (31.42), Kharchia Mutant (39.41), HP 1633 (51.44), DL 784-3 (42.77) and HW 2022 (49.53) were found on par with each other.

Yield and thousand grain weight: Maximum yield was recorded in the genotypes NIAW 34 (57.42 q/ha) followed by GW 349 (51.92 q/ha) and GW 322 (51.40 q/ha). The lowest yield was recorded on DWR 162 (30.61q/ha) followed by DWR 195 (36.53 q/ha) and DL 784-3 (39.35) under high leaf rust pressure (Table 2). Statistically, DWR 195 (36.53 q/ha) and MACS 2496 (40.81 q/ha) differed significantly from the rest of genotypes. The highest thousand grain weight was obtained in the genotype HP 1633 (50.33 g) followed by UP 2565 (49.00 g) and NIAW 34 (46.33 g). Least thousand grain weight was recorded in HW 2021 (32.00g) followed by DWR 162 (32.33g) and statistically they are on par with each other (Table 2).

Hasabnis *et al.* (2002) and Thombare (1981) reported similar results regarding ACI and AUDPC values. Similar results revealed by Nargund (1989) who identified DWR 39, HD 2189, HI 977, Keerti, Sonalika, WH 147 and WH 416 as slow leaf rusters on the basis of values of AUDPC. Navi (1986) identified C 464, DWR 39, HD 2189 and DWR 16 as slow rusters. Hasabnis and Srikant Kulkarni (2002) identified HD 2189 as slow ruster based on AUDPC values. Sabharwal (1986) identified Lal Bahadur and WL 711 as fast rusters and Arjun as slow ruster based on AUDPC and 'r' values.

Table 2. Performance of bread wheat genotypes against leaf rust and its effect on yield and 1000 grain weight.

Sl. No.	Genotype	Mean of 'r'	AUDPC	Grain yield (q/ha)	1000 grain weight (g)
1	DWR 195	0.034	1802.55	36.53	40.67
2	GW 322	0.057	662.01	51.40	40.33
3	RAJ 4037	0.060	703.44	49.49	42.00
4	NIAW 34	0.054	569.71	57.42	46.33
5	MACS 2496	0.049	1051.55	40.81	40.33
6	UP 2565	0.060	482.57	47.56	49.00
7	HD 2189	0.061	102.44	46.00	40.33
8	GW 344	0.042	610.47	45.05	41.33
9	GW 349	0.047	434.34	51.92	42.33
10	DWR 162	0..044	1621.67	30.61	32.33
11	HD 2160	0.132	321.12	45.17	42.00
12	WL 1562	0.044	36.42	45.57	45.33
13	HW 2021	0.054	171.23	43.48	32.00
14	HW 2008	0.038	4231	55.31	42.67
15	K. Mutant	0.031	39.41	41.54	40.33
16	HP 1633	0.037	51.44	43.61	50.33
17	DL 784-3	0.033	42.77	39.35	42.67
18	HW 2022	0.030`	49.53	50.09	40.33
	Mean	0.050	488.00	45.63	41.15
	SEm±	--	7.99	1.72	1.14
	CD at 5%	--	64.71	4.93	3.29

In general the genotypes with a stumpy initial leaf rust severity or delayed onset of the leaf rust invariably wrecked up with a low terminal disease severity and *vice-versa.* The terminal ACI was lesser in the genotype which showed later appearance of the disease and also depended on the presence and type of resistance genes. The genotypes with production of more number of infective units per day are considered as fast rusters. Results indicated that HD 2160 produced more number of mean infective units per day (0.132) as presented in Table 3 but the terminal disease severity was too low and yielded significantly higher than fast rusters. Whereas, DWR 195, DWR 162 and MACS 2496 with a mean infection rate of 0.034, 0.044 and 0.049 units per day showed a terminal disease severity of 100.00, 99.12 and 63.51 per cent, respectively and were rated as fast rusters.

The fast rusters showed lesser latent period. The lowest initial rate of infection was recorded in HW 2021 (0.04 units per day) followed by HD 2189 (0.058 units per day) between 40 and 47 DAS. Whereas, mean rate of infection was lowest in DWR 195 (0.035 units per day) followed by HW 2021 (0.040 units per day) and GW 344 (0.042 units per day), but only HD 2189 and HW 2021 showed lowest values of AUDPC. Similar results were obtained by Statler *et al.* (1977) and Gupta and Singh (1982).

In general, in the first disease week maximum 'r' value was observed on the genotypes wherein, early onset of disease (before 40 DAS) was noticed. Maximum 'r' value was between 40-47 DAS for genotypes wherein, delayed onset of the disease (after 47 DAS) was there and it was maximum between 47-54 DAS. Although, some exceptions are there for this responsiveness. In the genotype HP 1633 the maximum 'r' value was observed between 54-61 DAS and in genotype DL 784-3, HW 2021 and HW 2008 was between 61-68 DAS.

Longer latent period of slow rusting cultivars may be effective in reducing the rate of rust development (Johnson, 1980). Latent period was always found to be longer for all the cultivars in adult plant stage than in seedling stage (Kapoor, 1979). Cultivars with longer latent period, less production of uredospores per unit area, small pustule size rusted slowly (Sokhi and Singh, 1984).

Kapoor and Joshi (1981) reported that Sonalika, produced comparatively fewer flecks and pustule number per centimeter of leaf area than Agra Local. The latent period for Sonalika was longer by one to two days than for Kharchia and Agra Local. leaf rust developed slowly on cultivar that showed longer latent period and smaller and fewer uredia (Shaner and Finney, 1980).

It was noticed that the small value of average coefficient of infection (ACI) was optimistically correlated with a swell in the thousand grain weight. The yields of different genotypes differ with each other appreciably.

Khan and Trevathan (1997) revealed that the cultivars with moderately slow rusting nature, losses in the yield ranged from 8 to 19 per cent irrespective of cultivars. Although cultivars showing fast rusting responded as rust tolerant with respect to yield loss. AUDPC was highly correlated with the yield (Buchenau, 1975).

References

1. Anonymous (2006). Hand book of Agriculture, ICAR Publication, New Delhi. p. 845.
2. Buchenau GW (1975). Relationship between yield loss and area under stem and leaf rust progress curves. *Phytopathology* **65**: 1317-1318.
3. Gupta RP and Singh A (1982). Tolerance and slow rusting in wheat infected with *Puccinia recondita*. In: Proceedings of the *Second National Seminar on Genetics and Wheat Improvement. Hisar*, Feb: 18-20. 1980.
4. Hasabnis SN and Srikant Kulkarni (2002). Slow leaf rusting wheat genotypes. *Plant Pathology News Letter*. pp. 27-29.
5. Hasabnis SN, Lokhande SB and Wuike RV (2002). Durable resistance to leaf rust in wheat. *Journal of Maharashtra Agricultural University* **27**: 7-9.
6. Johnson DA (1980). Effect of low temperature on the latent period of slow and fast rusting winter wheat genotypes. *Plant Diseases* **64**: 1006-1008.
7. Joshi LM, Singh DV and Srivastava KD (1988). *Manual of Wheat Disease*. Malhotra Publishing House, New Delhi, p. 75.
8. Kapoor A and Joshi LM (1981). Studies on slow rusting of wheat. *Indian Phytopathology* **34**: 169-172.
9. Kapoor AS (1979). Preliminary investigations on the genetics of slow rusting in wheat. *Ph. D. Thesis, IARI*. New Delhi. p. 248.
10. Khan MA and Trevathan LE (1997). Economical analysis of fungicide application to manage leaf rust on winter wheat in Mississippi. *Pakistan Journal of Phytopathology* **9**: 34-40.
11. Kuhn RC, Ohm HW and Shaner GE (1978). Slow leaf rusting resistance in wheat against twenty two isolates of *Puccinia recondita*. *Phytopatholgy* **68**: 651-656.
12. Nargund VB (1989) Epidemiology and control of leaf rust of wheat caused by *Puccinia recondita* f.sp. *tritici*. *Ph. D. Thesis,* U.A.S., Dharwad. p. 337.
13. Navi SS (1986). Studies on leaf rust of wheat caused by *Puccinia recondita* f.sp. *tritici* Rob. ex. Desm. M. SC. (Agri) Thesis, University of Agricultural Sciences, Dharwad, p. 121.
14. Ohm HW and Shaner GE (1976). Three components of slow leaf rusting at different growth stages in wheat. *Phytopathology* **6:** 1356-1360.
15. Peterson RE, Campbell AB and Hannah AE (1948). A digramatic scale for estimating rust intensity of leaves and stems of cereals. *Canadian Journal of Research* **26**: 496-500.
16. Sabharwal R (1986). Studies on pathological and biological parameters *vis a vis* rate of leaf rust development in certain wheat varieties. M. Sc. Thesis, IARI, New Delhi. p. 165.
17. Shaner G and Finney RE (1980). New resources of slow leaf rusting resistance in wheat. *Phytopatholgy* **70**: 1183-1186.
18. Sokhi SS and Singh BB (1984). Components of slow rusting in pearl millet infected with *Puccinia pennisetii*. *Indian Journal of Mycology and Plant Pathology* **14:**:190-192.
19. Statler GD, Norgaard and Watkins JE (1977). Slow leaf rust development in durum wheat. *Canadian Journal of Botany* **55**: 1539-1543.
20. Thombare SB (1981). Studies on slow rusting mechanism in certain wheat varieties. Report on the coordinated experiments. Wheat Pathology (Indian Agricultural Research Institute, New Delhi). 1980-81. p. 118-123.
21. Van Der Plank JE (1968). Disease Resistance in Plant, Academic Press, New York, p. 206.
22. Wilcoxson RD, Skovmand B and Atif AH (1975). Evaluation of wheat cultivars for ability to retard development of stem rust. *Annals of Applied Biology* **80**: 275-281.