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Screening and characterization of adult plant resistance for stripe rust of wheat

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Abstract
Wheat is the second most important cereal crop of the world facing serious threat by three rusts of wheat, stripe rust is the most devastating disease of wheat rust mainly occurs in the cool climatic conditions with an optimum temperature of 18-20 ºC, which reduce the yield.Durable and adult plant resistance plays a crucial role as compare to seedling resistance which showed differential response to different pathotypes by decreasing latent period, sporulation rate, rate of infection and assessment of partial resistance with help of Coefficient of infection, AUDPC and rAUDPC values. most efficient parameters for assessing slow rusting. The present research findings reveles that 7germplasm namely G4, G5, G34, G39, G42, G43, G50 showed the immune response while 13 germplasm namely with are resistant RMR and 5 germplasm with MR 7 germplasm with MRMS. Area under disease progress curve values 10-100 in 18 lines. AUDPC values < 200 were considered as, slow ruster germplasm with higher field efficacy and the germplasm which were representing < 30 % are of rAUDPC comes under high levels of slow rusting.

Keywords: Germplasm, slow rusting, AUDPC, Coefficient of infection

Introduction

Stripe rust of wheat a devasting pathogen of the wheat which can lead losses up to 70-100 % (Prashar *et al*., 2007) [6] yield losses during the epidemics. The rapid evolution of the new races raises concern for mining of the new resistant genes against the emerging races of the pathogen, but the durability of the race specific genes is one of the important challenges against new pathotypes (Sandoval-Islas *et al*., 2007) [8]. The characterization of the rust resistance in two categories is seedling resistance (SR) and Adult plant Resistance (APR) (Saeed *et al*., 2022) [7], SR which is different from the APR gene resistance which could be break down easily by the emergence of the new virulent races of the pathogen (McIntosh *et al*., 2018) [4]. The field-based assessment of the different disease paraments for the identification of the partial resistance germplasm one of the important steps in development of the resistance breeding programme. Partial resistance which is durable for long time, so that the present research was emphasized to identify the partial resistance or slow rusting lines which are more durable and will help in the further exploitation for development of new resistance lines of breeding programmes.

Material and Methods

1. Plant material

The plant material utilized in the present study for screening of elite germplasm which was provided by the AICRP – wheat and barley, Division of Plant Breeding and Genetics, SKUAST, Jammu, 50 bread wheat germplasm screened from ICARDA nursery along with two cultivars PBW343 and HD2967 andone Agra local used as susceptible controls. Artificial inoculations were carried out by using a spore's mixture of the most prevalent yellow rust pathotypes46S119, 110S84, 110S119 and 47S103 on susceptible lines andspray of spore suspensionwere applied on the field. inoculation of suspension sprayed on tested germplasm and susceptible lines. Disease observation were recorded at the first appearance of stripe rust infection on the germplasm and susceptible Agra local. Observations severity and their disease response on tested germplasm and susceptible check stripe rust were recorded according to Loegering (1959)

Table 1: Disease response value with type of infection according to Loegering (1959)

S.no	Reaction	Observation	Response value
1.	No Disease	0	0
2.	Resistant	R	0.2
3.	Resistant to Moderately Resistant	RMR	0.3
4.	Moderately Resistant	MR	0.4
5.	Moderately Resistant to Moderately Susceptible	MRMS	0.6
6.	Moderately Susceptible	MS	0.8
7.	Moderately Susceptible to Susceptible	MSS	0.9
8.	Susceptible	S	1

Legend: R: Resistant; RMR: Resistant to Moderately Resistant; MR: Moderately Resistant; MRMS: Moderately Resistant to Moderately Susceptible; MSS: Moderately Susceptible to Susceptible; MS: Moderately Susceptible; S: Susceptible.

Table 2: Categorization of partial resistance or slow rusting germplasm based on the different parameters of parameters

Category / level of Slow Rusting / Adult Plant Resistance	FRS value (%)	CI Value	rAURPC value	AUDPC
High	1-20%	0-20	up to 30% of the check	1-100
Moderate	21-40%	21-40	up to 40% of the check	100-200
Low	41-60%	41-60	up to 60% of the check	200-400
Susceptible	61-100%	61-100	100%	>500

Stastical Analysis

Coefficient of Infection

The coefficient of infection (CI) was calculated by combining the disease severity and the response value by (Akhtar *et al*., 2002) [1]

Coefficient of infection = Disease severity x Response value

Area Under Disease Progress Curve (AUDPC)

Slow rusting or APR genes resistance has been classified in to three different categories such R-1-200: MR-201-400; S ->400 to identify the APR components based on the disease severity of the stripe rust. (Vaibhav *et al*., 2017) [10]

Relative Area Under Disease Progress Curve (rAUPDC)

Relative area under disease progress curve is calculated comparing the line AUDPC with control AUDPC values. (Akhtar *et al*., 2002 [1]; Attri and Dey, 2021) [3]

Results and discussion

Table 3: Response of the screened germplasm for stripe rust disease severity, AUDPC and RAUDPC values.

S.NO	GERMPLASM	FRS	CI	AUDPC	RAUDPC
1	G1	10RMR	3	25.2	3.2
2	G2	30MRMS	18	199.5	25.6
3	G3	20RMR	6	77.7	10.0
4	G4	40MS	32	322	41.3
5	G5	TR	0	0	0.0
6	G6	30MRMS	18	182	23.3
7	G7	20MS	16	294	37.7
8	G8	10RMR	3	46.2	5.9
9	G9	20RMR	6	80.5	10.3
10	G10	10R	2	21	2.7
11	G11	5R	1	3.5	0.4
12	G12	20MR	8	112	14.4
13	G13	20MSS	18	287	36.8
14	G14	40S	40	560	71.8
15	G15	TR	0	0	0.0
16	G16	20RMR	6	94.5	12.1
17	G17	20MRMS	12	147	18.9
18	G18	10R	2	18.2	2.3
19	G19	10RMR	3	9	1.2
20	G20	60MSS	54	763	97.9
21	G21	30MRMS	12	140	18.0
22	G22	10RMR	3	28	3.6
23	G23	20MSS	18	245	31.4
24	G24	40MS	32	462	59.3
25	G25	5RMR	1.5	17.15	2.2
26	G26	20RMR	6	84	10.8
27	G27	20RMR	6	84	10.8
28	G28	30MR	12	133	17.1
29	G29	30MS	24	350	44.9
30	G30	20RMR	6	94.5	12.1
31	G31	20RMR	6	91	11.7
32	G32	30RMR	9	88.2	11.3
33	G33	60S	60	857.5	110.0
34	G34	0	0	0	0.0
35	G35	10R	2	14	1.8
36	G36	10RMR	3	31.5	4.0
37	G37	30MR	12	140	18.0
38	G38	3R	0.6	3.5	0.4
39	G39	0	0	0	0.0
40	G40	40S	40	612.5	78.6
41	G41	10R	2	18.2	2.3
42	G42	40MS	32	462	59.3

43	G43	20MS	16	224	28.7
44	G44	20MR	8	107.1	13.7
45	G45	20MR	8	121.1	15.5
46	G46	30MRMS	18	178.5	22.9
47	G47	60S	60	1015	130.2
48	G48	0	0	0	0.0
49	G49	5R	1	0	0.0
50	G50	0	0	0	0.0
51	Agra local	70S	70	880	98.8
52	PBW343	50S	50	720	106.4
53	HD2967	60S	60	680	74.32
	S. E		2.53	5.23	7.23
	CD (5%)		4.32	6.43	6.32

1. Coefficient of Infection

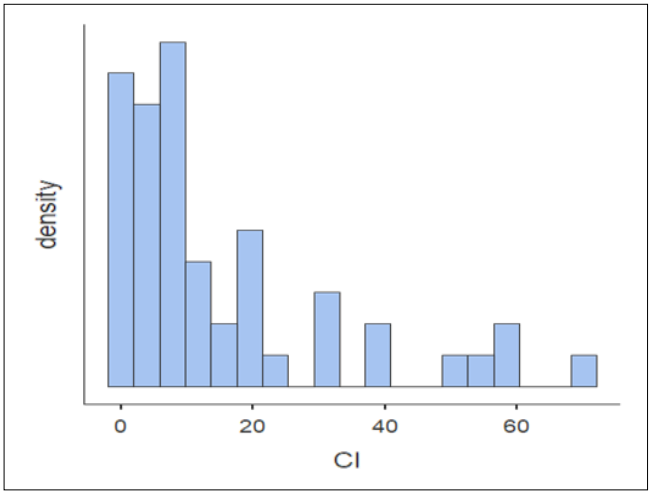
The coefficient of the infection values reveled that disease patterns of the stripe rust among the screening of germplasm showed that 6 germplasm (G4, G5, G34, G39, G42, G43, G50) seedling resistance with major race -specific genes. The trace type of disease severity TR to Resistance (R) was recorded in 7 germplasm(G5,G10,G11,G15,G18,G35,G38,G49) where it indicates there is highly resistant germplasm which also confers by race -specific genes CI values 0-2, 13 germplasm showed RMR type (G3,G8,G9,G16,G19,G26,G27,G30,G31,G32and G36) of the reaction where it indicates that the presence of the strong race specific associate with minor genes which is durable in nature with CI value 3-6. 7 germplasm (G12, G25, G28, G37, G44 and G45)showed Moderately resistant (MR) with CI values, 5 germplasm (G2, G6, G16, G29 and G46) with (MRMS) type of disease reaction with CI values 13-18, 6germplasm with (G4, G7, G24,G29, G42 and G43) (MS) with CI values of 16-32%. 3 germplasm out of 50 shows MSS (G10, G13, G23) type of reaction with CI values of 18-54 and 3 germplasm are found susceptible with diseases reaction S (G51, G52 and G53) with CI values 40-60.

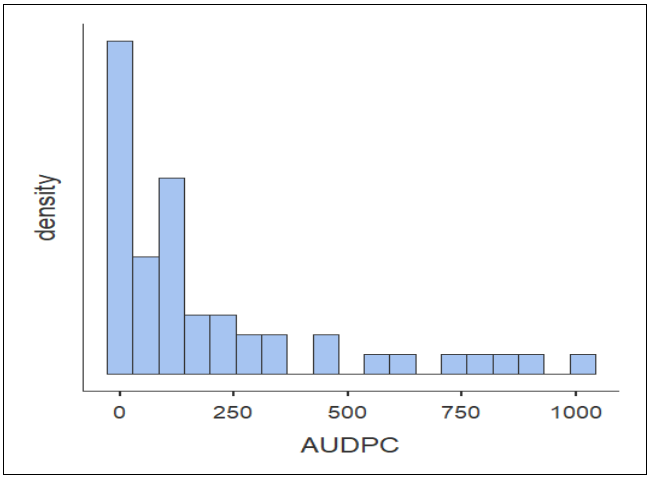
2. Area under Disease Progress Curve (AUDPC)

AUDPC is one of the important disease parameters for the quantification of the sow rust germplasmin which the germplasm categorized as the values 0 recorded in 6 germplasm which indicate the resistance,the AUDPC value 1-10 was observed in 2 germplasm comes under highly resistant and 15 germplasm which comes under the category of 11-100 (G3,G8,G9,G16,G19,G26,G27,G30,G31,G32and G36) which indicated the high levels of the slow rusting genes, 11 germplasm observed with AUDPC values of 100-200 in which are regarded as the most efficient germplasm ((G12, G25, G28, G37, G44,G45,G2, G6, G16, G29 and G46)) and spreading of rust will be much slower rate than comparing to check and 2 germplasm (G10, G13) observed with AUDPC values 400-500 with low levels of slow rusting genes and 5 germplasm (G10, G13, G23, G6, G16) observed AUDPC more than 800.

3. Relative Area Under Disease Progress Curve (rAUDPC)

RAUDPC values of the screened germplasm are categorized in to 4 different levels by comparing the AUDPC values of the susceptible checks, the germplasmwhich are showing rADUPC values less than up to 30 are considered as the most efficient to slow rusting genes and also contains the germplasm with many vertical resistance genes noticed in 36 germplasm(G3, G8, G9, G16, G19, G26, G27,G30,G31,G32, G36, G12, G25, G28, G37, G44 and G45)and rAUDPC values up to 40 % comes under the level of the moderate level of slow rusting or adult plant resistance genes 5 germplasm was observed under this category and values up to 60% was observed in 5 germplasm (G10, G13, G23, G51, G52 and G53) of the screened germplasm and susceptible checks and 5 germplasm of the screened germplasm was also identified that rAUDPC values up to 100% found to be more susceptible





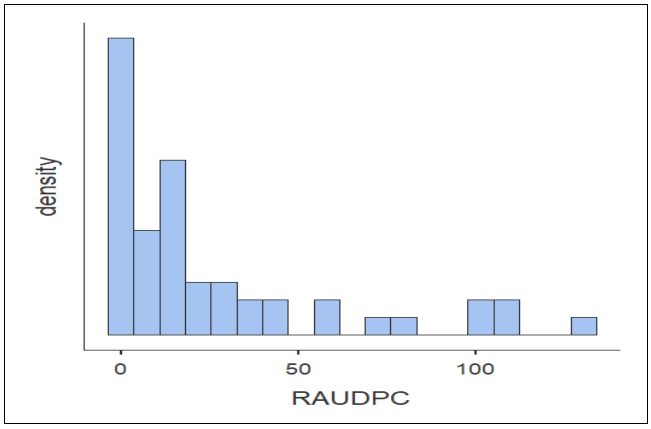


Fig 1: Graphical representation of CI, AUDPC and RAUDPC values of the screened germplasm of wheat for stripe rust

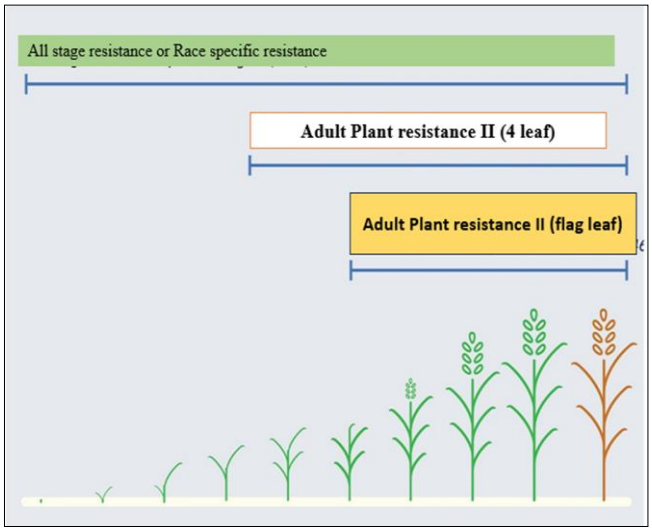
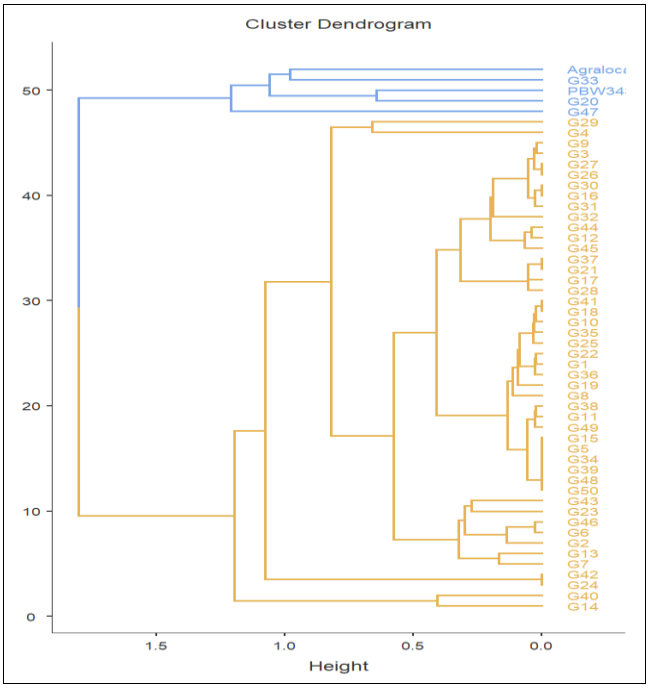


Fig 2: Stage wise resistance of the plant at different phenological stages

4. Cluster Dendrogram

Cluster dendrogram analysis of the screened germplasm based on the coefficient of infection AUDPC and RAUDPC values divided them in to two clusters which the germplasm germplasm Agra local, PBW343, G20, G47 germplasm comes under the cluster 1 which are representing the high coefficient of infection, Area under disease progress curve and Relative area under disease progress curve. The germplasm G29, G4, G9, G3, G27, G26, G30, G16, G31, G32, G44, G12, G45, G37, G21, G17, comes under second category where the most of the immune response germplasm and highly resistant germplasm comes under this category and most of the germplasm which showing immune response and highly resistant values are most probable avirulence to the many of the pathotypes which are prevalent in the region and germplasm which are showing infection values from moderate to moderate susceptible are.comes under the slow rusting category and these germplasm are considered as the most durable in nature for the field efficacy and these germplasm with slow rust rusting resistance may be associated with another major gene resistance in the combating the virulence of the pathogen



Discussion

Management of stripe rust through spray of chemical fungicides one of the important factor in plant disease management but the raise in concern of the environmental risk factors and pathogen resistance make us to think the alternative strategies for management Host resistance is one of the major approach in the management of the disease but the change in virulence patterns of resistance governed by the gene against pathogen is one of the major issue to overcome this the durability of the gene plays one of the crucial factors to combat the disease, the horizontal resistance or minor genes which are more durable and with good field efficacy along with different combinations of the genes, the characterization of the slow rusting resistance with various phenotypic disease screening parameters help in identification of the durable resistance among the screened germplasm. Slow rusting or APR genes resistance categorization based on the phenotypic expression of disease severity by using the AUPDC divided into different classes like susceptible, moderately resistant MR and R depends on the values; R-1-200:MR-201-400; S - >400 (Attri and Dey, 2021) [3] to identify the APR components in different germplasm of wheat. CI values of 0-20, 21-40, 41-60 (Pathan and Park, 2006) [5] represents the high, moderate and low levels of APR are strongly supported with previous research findings of (Ali *et al.*, 2008) [2]; rAURPC values less than 30 % of the susceptible checks shows better partial resistance and finally, the FRS values, 1-20,21-40 and 41-60,(Shahin *et al.*, 2021) [9] shows a high, moderate and low level of the partial resistance, the strong correlation between FRS, rAURPC for selecting durable resistance germplasm(Ali *et al.*, 2008 [2]; Vaibhav *et al.*, 2017) [10]. The germplasm lines which are screened are significant difference between susceptible checks compare to table value at 0.05%.

Summary and Conclusion

The present research findings concluded that seven germplasm possess ASR or All Stage Resistance, the durable resistance germplasm with AUDPC values and CI values with 10-20 and 100-200 are most durable at field

capacity and the AUDPC germplasm ranges 200 are slow rusting in nature when compared to the fast-rusting susceptible checks under field conditions and there should be further studied for their efficient use.

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