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ORIGINAL ARTICLE

Resistance Potential of Wheat Germplasm against Stripe and Leaf Rust in Sargodha

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ABSTRACT
Wheat rusts are serious threat worldwide and cause a significant loss in yield more than 90% in case of susceptible variety under epidemic conditions. Among them, Yellow and brown rusts caused by Puccinia striiformis f. sp. tritici and Puccinia recondite f. sp.tritici, respectively are serious threat to wheat production in cooler areas of Pakistan. Losses due to the infection of these diseases caused decreased in wheat production. Rusts can be avoided by incorporating resistance in wheat. The objective of current study was to identify resistance sources of wheat against yellow and brown rusts by screening wheat germplasm in Sargodha. For this purpose, one hundred wheat varieties were sown in field conditions at the research area of Department of Plant Pathology, College of Agriculture, University of Sargodha. The nursery was surrounded by four rows of Morocco to increase the inoculum pressure. The yellow and brown rusts severity data were recorded at an interval of seven days by following modified Cobb's scale up to physical maturity. When the severity of spreader was near to 100%, final data was collected. Results revealed thatout of hundred sown varieties, ninety seven germinated. These varieties were screened against stripe and leaf rusts. Against stripe rust, out of 97 varieties, 19 were moderately resistant, 16 were resistant, 23 were moderately susceptible and 11 were susceptible. Against leaf rust out of 97, six varieties were moderately susceptible, six were susceptible, two varieties were resistant and 85 varieties did not show any symptom to leaf rust. The current study revealed that incidence of stripe rust was more than brown rust in Sargodha. Secondly, varieties showed more response to stripe rust than brown rust.
Key Words: wheat, rust, screening, resistant, stripe rust

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second-most important food crop which provides a large supply of the dietary proteins and grown all over the world [1, 2].Wheat is an important cereal crop which has been cultivated for thousands of years [3]. Wheat is good source of amino acids as well as minerals [4]and shares 7.3% value added in agriculture. Pakistan is facing the challenges in producing enough wheat due to drastic increase in population [5]. The production of wheat in our country is low as compared to other advanced countries due to various biotic and abiotic factors. Among them, rusts are major fungal diseases which attack the wheat. Worldwide, rusts are most important diseases due to its wide distribution, potential to produce rapid infection and ability to travel long distances. Rust diseases are among the significant factors of wheat and cause yield losses upto 70% under favorable conditions in susceptible cultivars [6, 7]. Pathogen of stripe rust can survive up to -4^{o}C in winter. On other hand Leaf rust has dark brown spores and spreads through water and air currents. Wheat is primary host of leaf rust. The safeguard measures against destructive plant pathogen are therefore, utmost in the framework of food safety[8]. However, genetically improved wheat varieties are the most efficient method. Sowing of resistant varieties is best management practice to reduce stripe and leaf rusts. Resistant cultivars are identified on the basis of screening. Therefore, current study was planned to screen different wheat germplasms against stripe and leaf rust.

MATERIAL AND METHODS

Present research was carried out in experimental field of Department of Plant Pathology located in College of Agriculture (CoA), University of Sargodha, Sargodha (UOS) during 2016-17.

Collection of germplasm

Hundred varieties/lines were collected from Department of Plant Breeding and Genetics, CoA, UOS, tagged with numbers and stored at room temperature.

Sowing

Experimental area was prepared. All varieties were sown in augmented design. After each five varieties of experiment, Morocco was sown as spreader. The length of each line was 4.5 meter. Varieties were sown in first week of December 2016. Cultural practices were done for better crop growth and development.

Inoculum preparation

Stripe and leaf rusts were applied as inoculums. Infected leaves of stripe/leaf rust were collected and applied as inoculums by following two application methods

Dusting: The infected leaves were mixed in talcum powder and then this powder was dusted in field three times with an interval of one week.

Spraying: Heavily infested stripe/leaf rusts leaves were mixed in water tank and sprayed through sprayer.

Data collection

After appearance of initial symptoms of stripe and leaf rusts, the readings were taken on the basis of specific scale named Cobb›s scale [9]. Mostly data was collected three times with the interval of one week. Results were given on the basis of susceptibility and resistance of varieties.

Screening of wheat germplasm

The experiment was conducted during 2016-17. A total of one hundred lines /varieties were sown in such a way that one variety has one row of 5 meter length. The several lines of Morocco were sown in surroundings of experiment to increase the inoculums pressure. The whole plot was inoculated by dusting and spraying methods to maintain rust inoculum pressure. This practice was conducted four times in month. The specific irrigation and fertilization schedule was used to keep the crop healthy. Data of stripe and leaf rusts was collected on 16th and 23th of March, and 6th of April, 2017, with interval of 7 days.When Morocco became 100% susceptible, disease severity data of stripe/leaf rusts was collected from different varieties/lines.

Epidemiological factors affecting the stripe and leaf rust diseases:

One hundred lines were sown and Morocco was used as rust spreader. No fungicide was used while spray inoculum was applied four times in a month to increase disease pressure. The normal agronomic practices were also done for making crop stand vigorous.

Conventional instruments were used for the collection of environmental data including maximum and minimum air temperatures, relative humidity, rainfall and wind speed. Instruments were closely fixed to experimental area. Relationship between environmental factors and stripe/leaf rusts was determined using regression models. Environmental data served as independent variable and disease severity data served as dependent variable. Line Graphs were plotted to show the relationship between environmental variables and disease severity [10,11].

RESULTS

Response of varieties/lines

One hundred lines were screened against stripe rust. 97 varieties showed different responses against yellow rust (Table 1). Three lines were not examined due to absence of their germination. Out of 97 lines, the remaining 28 lines were screened as immune. Out of 97 varieties, 28 lines were immune, 19 lines were resistant, 16 lines were moderately resistant, 23 lines were moderately susceptible and 11 lines were susceptible. The data was collected three times with the interval of one week but the last data was collected after 10 days. The symptoms of stripe rust were observed 20 days before the appearance of symptoms of leaf rust.

Table: 1 Response of different varieties/lines against yellow rust

	Disease rating scale				Disease rating scale		
Varieties /Lines	**16-3-2017**	**23-3-2017**	**03-04-2017**	Varieties /Lines	**16-3-2017**	**23-3-2017**	**03-04-2017**
PYT-15-16 P-7 V-7 (UOS)	5R	7R	20R	G1 UOS – 694	0	0	0
PYT-15-16 P-9 V-9 (UOS)	0	10R	20R	G1 UOS – 699	40MS	20MS	100S
PYT-15-16 P-11 V-11 (UOS)	20MR	23MS	R	G1 UOS - 698	40MS	20MS	80MS
PYT-15-16 P-35 V-35 (UOS)	0	0	10R	G1 UOS – 697	5MR	10MR	20R
UOS 262	0	20R	5R	G1 UOS – 696	5MR	10MR	10R
P-10 V-10	0	0	10MR	G1 UOS – 695	5R	10R	20MR
PYT-40 (F-2) PYT-2	5MR	7MR	5R	FSD – 08 P-49(Not grown)			
P-5 V-5 (UOS)	R	2R	5R	PAWYT-2016-17 (UOS-12)	30MS	50MS	40MS
P-3 V-3	5R	6R	10R	UOS 142 G3 A-T	0	0	0
P-16 V-16	10MS	10MS	50MS	UOS 317(94)(G4)	0	0	0
P-18 V- 18	5R	6R	10R	UOS 315 P_1V_2(kayam)	5R	10R	20MS
P-6 V-6	30MS	30MS	60S	UOS 133 A-T (G3)	0	5MR	30MS
P-17 V-17	10MR	10MS	50MS	G4 UOS 280	R	10MR	20MR
P-13 V-13	10R	11R	40MS	G4 UOS 238	10MS	10MS	60S
P-15 V-15	20MS	22MS	80S	G4 UOS 284	5R	10R	50MS
UOS -519	30MS	30MS	60MS	G4 UOS 285	20R	25R	40MS
P-14 V-14	30MR	30MR	20MR	G4 UOS 405	20MR	10MS	80S
CB – 179	2MR	2MR	20MR	G4 UOS 403	0	0	20MR
UOS – 250	10R	30R	40R	G4 UOS 401	0	0	0
PYT-2 P-40	0	0	40MS	PYT – 1 P-21	10MS	20MS	60MS
PYT – 2 P – 70	20MS	20MS	80S	PYT-2 P-179	0	0	0
UOS – 503	0	0	0	Heat P-77	0	0	20MR
UOS – 291	10MR	10MR	20MS	PYT -2 P-19	5MS	10MS	10MS
P-8 V-8	40MS	40MS	60S	UOS 118 G3 A-T	0	0	0
P-2 V-2	40MR	40MR	R	UOS 140 G3 A-T	0	0	0
F-2 P-39	10MR	20MR	60S	UOS 139 G3 A-T	0	0	0
UOS – 256	10MR	15MR	60S	UOS 306 G4	20MS	25MS	50MS
P-1 V-1	10MS	50MS	80S	UOS 305 G4	0	0	0
U0S-509	0	0	0	G4 UOS 304	20MS	10MS	50MS
UOS -505	5R	10R	60MS	G4 UOS 303	0	0	10MR
UOS – 512	0	0	0	UOS 267 (15,16)	0	0	20MR
P – 38	10MR	10MR	10R	P-64 UCA (P-22)	0	0	0
UOS – 504	60S	60S	50S	G4 UOS 313	10MS	10MS	30MS
G3 UOS – 157	0	0	0	G4 UOS 310	0	0	0
G3 UOS – 156	0	0	0	G4 UOS 307	0	0	70MS
G3 UOS – 155	0	0	0	G3 UOS 122	20MS	15MS	30MS
G4 UOS – 227	10R	15MR	20MR	G3 A-T UOS 119	30MS	30MS	30MS
G4 UOS – 402	10MR	30MR	10R	Heat p-12 (Not grown)			

G4 UOS – 225	0	0	0	PYT –1 P-17	10MR	15MR	10MR
G4 UOS – 224	0	0	0	PYT – 2 P-91	10S	20MS	60MS
G3 UOS - 158	0	0	0	PYT – 2 P-48	0	30MR	10R
G4 UOS – 412	0	0	0	PYT -2 P-105	0	0	0
G4 UOS – 411	0	0	0	G3 UOS 134	20MS	30MS	30MR
SAWSN – E – 29	0	0	0	G3 A-T UOS 132	10MR	10MR	20MR
SAWSN – E – 27	5R	10MR	5R	G4 UOS 247	25MS	25MS	40MS
SAWSN – E – 201	5R	10R	10MR	G4 UOS 296	0	0	0
G4 UOS – 319	0	0	0	G4 UOS 293	10MS	10MS	10R
G4 UOS – 318	0	0	0	G3 UOS 131 A-T	0	0	0
(2016) NUWYT V_2 FROM D_4K	0	0	0	UOS 299(Not grown)			
G1 UOS - 692	5R	10R	10R	G4 UOS 137 A-T	10MS	20MS	40MS

Different varieties reaction against brown rust:

The leaf rust was also examined on one hundred lines which were screened against yellow rust. The symptoms of leaf rust were showed after the stripe rust and most of varieties were immune. Out of 97 varieties six were moderately susceptible, six were resistant and remaining 85 varieties were immune. This response was showed by leaf rust on third screening (Table 2).

Table 2: Response of different varieties/lines against leaf rust

	Disease rating scale				Disease rating scale		
Varieties /Lines	**16-3-2017**	**23-3-2017**	**03-04-2017**	Varieties /Lines	**16-3-2017**	**23-3-2017**	**03-04-2017**
PYT-15-16 P-7 V-7 (UOS)	0	0	0	G1 UOS – 694	0	5MS	40MS
PYT-15-16 P-9 V-9 (UOS)	0	0	0	G1 UOS – 699	0	0	0
PYT-15-16 P-11 V-11 (UOS)	0	0	0	G1 UOS - 698	0	0	0
PYT-15-16 P-35 V-35 (UOS)	0	0	0	G1 UOS – 697	0	0	0
UOS 262	0	0	0	G1 UOS – 696	0	0	0
P-10 V-10	0	0	0	G1 UOS – 695	0	0	0
PYT-40 (F-2) PYT-2	0	0	0	FSD – 08 P-49	0	0	0
P-5 V-5 (UOS)	0	0	0	PAWYT-2016-17 (UOS-12)	0	0	0
P-3 V-3	0	0	0	UOS 142 G3 A-T	0	0	0
P-16 V-16	0	0	0	UOS 317(94)(G4)	0	0	0
P-18 V- 18	0	0	0	UOS 315 P_1V_2(kayam)	0	0	0
P-6 V-6	0	0	0	UOS 133 A-T (G3)	0	0	0
P-17 V-17	0	0	0	G4 UOS 280	0	0	0
P-13 V-13	0	0	0	G4 UOS 238	0	0	0
P-15 V-15	0	0	0	G4 UOS 284	0	0	0
UOS -519	0	0	0	G4 UOS 285	0	0	0
P-14 V-14	0	0	0	G4 UOS 405	0	0	0
CB – 179	0	0	0	G4 UOS 403	0	0	0
UOS – 250	0	0	0	G4 UOS 401	0	0	0
PYT-2 P-40	0	0	0	PYT – 1 P-21	0	0	0

PYT – 2 P – 70	0	0	0	PYT-2 P-179	0	0	0
UOS – 503	0	0	0	Heat P-77	0	0	0
UOS – 291	0	0	0	PYT -2 P-19	0	0	0
P-8 V-8	0	0	0	UOS 118 G3 A-T	0	0	0
P-2 V-2	0	0	0	UOS 140 G3 A-T	0	0	0
F-2 P-39	0	0	0	UOS 139 G3 A-T	0	0	100S
UOS – 256	0	0	0	UOS 306 G4	0	0	60S
P-1 V-1	0	0	0	UOS 305 G4	0	0	0
U0S-509	0	0	40S	G4 UOS 304	0	0	0
UOS -505	0	0	10MS	G4 UOS 303	0	0	0
UOS – 512	0	0		UOS 267 (15,16)	0	0	0
P – 38	0	0	10MS	P-64 UCA (P-22)	0	0	0
UOS – 504	0	0		G4 UOS 313	0	0	0
G3 UOS – 157	0	0		G4 UOS 310	0	0	0
G3 UOS – 156	0	0	20S	G4 UOS 307	0	0	0
G3 UOS – 155	0	0		G3 UOS 122	0	0	0
G4 UOS – 227	0	0		G3 A-T UOS 119	0	0	0
G4 UOS – 402	0	0	20MS	Heat p-12	0	0	0
G4 UOS – 225	0	0	0	PYT –1 P-17	0	0	0
G4 UOS – 224	0	0	0	PYT – 2 P-91	0	0	0
G3 UOS - 158	0	0	0	PYT – 2 P-48	0	0	0
G4 UOS – 412	0	0	0	PYT -2 P-105	0	0	0
G4 UOS – 411	0	0	0	G3 UOS 134	0	0	20MS
SAWSN – E – 29	0	0	5R	G3 A-T UOS 132	0	0	40S
SAWSN – E – 27	0	0	0	G4 UOS 247	0	0	0
SAWSN – E – 201	0	0	0	G4 UOS 296	0	0	0
G4 UOS – 319	0	0	5R	G4 UOS 293	0	0	0
G4 UOS – 318	0	0	0	G3 UOS 131 A-T	0	0	60S
(2016) NUWYT V_2 FROM D_4K	0	0	0	UOS 299	0	0	20MS
G1 UOS - 692	0	0	0	G4 UOS 137 A-T	0	0	0

S= Susceptible; R = Resistant; MS = Moderately susceptible.; MR = Moderately Resistant.; 0= Immune

Area under yellow rust disease progress curve

AUDPC of each variety was examined and calculated. Different varieties showed different AUDPC. The varieties which showed maximum AUDPC were highly susceptible against yellow rust. The varieties which showed low amount of AUDPC were moderately susceptible against yellow rust. Five varieties showed AUDPC values in the range of 150-250, one variety 250-300, six varieties in the range 300-400, nine varieties in the range of 500-700 and eight varieties showed AUDPC in the range of 700-1000. So the last eight varieties were highly susceptible against yellow rust (Table 3).

Area under leaf rust disease progress curve

AUDPC of brown rust was also calculated. The leaf rust appearance was lower than yellow rust. Twelve varieties showed response and 85 varieties were asymptomatic against leaf rust. Two varieties showed AUDPC 1-60, three varieties showed AUDPC 70-200, six varieties showed AUDPC 210-500 and one variety showed 600-1000 AUDPC. The varieties which showed maximum AUDPC were;UOS 299, G3 UOS 134, UOS 139 G3, A-TG1 UOS – 694, G3 UOS – 156 and G4 UOS – 40 (Table 4).

Table 3 Area under yellow rust disease progress curve

Area under yellow rust disease progress curve		Area under yellow rust disease progress curve	
Variety/lines	AUDPC	Variety/lines	AUDPC
PYT-2 P-40 UOS – 291 UOS 315 P_1V_2(kayam) UOS 133 A-T (G3) PYT -2 P-19	150-250	UOS – 256 UOS -505 G4 UOS 238 G4 UOS 304 G4 UOS 137 A-T	400-500
G4 UOS 313	250-300	PYT – 2 P – 70 F-2 P-39 G4 UOS 285 G4 UOS 405 PYT – 1 P-21 UOS 306 G4 G3 A-T UOS 119 PYT – 2 P-91 G4 UOS 247	500-700
P-16 V-16 P-17 V-17 P-13 V-13 G4 UOS 284 G4 UOS 307 G3 UOS 122	300-400	P-6 V-6 P-15 V-15 UOS -519 P-8 V-8 P-1 V-1 G1 UOS – 699 G1 UOS - 698 PAWYT-2016-17 (UOS-12)	700-1000

Table 4 Area under leaf rust disease progress curve

Varieties/Lines	AUDPC
U0S-509 UOS -505	1-60
G3 UOS 131 A-T G3 A-T UOS 132 P – 38	70-200
UOS 299 G3 UOS 134 UOS 139 G3 A-T G1 UOS – 694 G3 UOS – 156 G4 UOS – 402	210-500
UOS 306 G4	600-1000

Relationship between Environmental Factors

Yellow rust correlation was significant with maximum and minimum temperatures, relative humidity and wind speed.

Stripe rust vs. maximum Temperature

Effect of maximum temperature on different varieties was different. The correlation was positive with disease severity of two varieties G1 UOS-699 and P-1 V-1. With increase in maximum temperature, the disease also increased. Linear regression models showed R^2 values in the range of 0.99 and 0.52, respectively.

Minimum temperature vs stripe rust

Minimum temperature also affected stripe rust disease severity on two varieties differently. This relationship was positive between minimum temperature and stripe rust diseease severity on the varietiesG1 UOS-699 and P-1 V-1. The R^2 values were 0.94 and 0.79, respectively.

Stripe rust vs. relative humidity

Relative humidity (RH) did not show significant relationship with stripe rust disease severity; however, the not significant relationship remained positive on two highly susceptible varietiesG1 UOS-699 and P-1 V-1. This relationship was poorly explained by linear regression models by 0.008 and 0.34, respectively on two varieties.

Stripe rust vs. wind speed

Wind speed relationship was also significant. Increase in wind speed increased stripe rust disease severity. The relationship was explained by linear regression models as indicated by R^2 values 0.48 and 0.79, on varietiesG1 UOS-699 and P-1 V-1 respectively.

Leaf rust vs. maximum temperature

Effect of maximum temperature on disease severity of leaf rust of varieties G4 UOS-306 and G4 UOS 402 was positive and significant. With increase in temperature, disease severity of leaf rust also increased. Linear regression models R^2 values remained 0.47 and 0.47, respectively on two varieties.

Leaf rust vs. minimum temperature

Minimum temperature also affected disease severity of leaf rust on two varieties G4 UOS-306 and G4 UOS-402. The relationship was positive with R^2 values 0.91 and 0.91, respectively on two varieties.

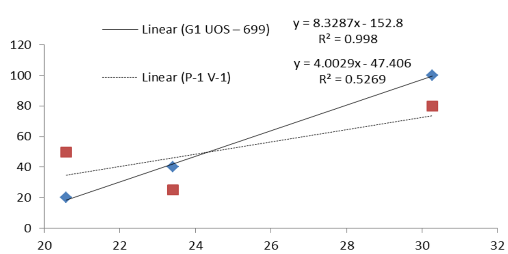
Leaf rust vs. relative humidity

Relative humidity (RH) also affected leaf rust. The relationship of RH with disease severity of leaf rust on two highly susceptible varietiesG4 UOS-402 and G4 UOS-306 was positive and significant. This relationship was best explained by linear regression models by 0.43 and 0.43, respectively.

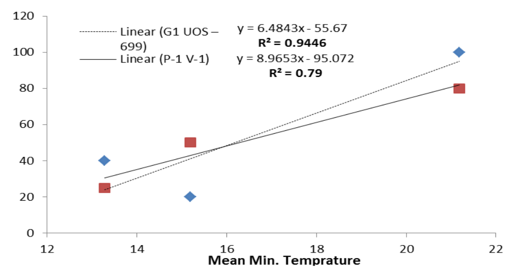
Leaf rust vs. wind speed

Wind speed relationship with leaf rust disease severity was not significant; however, increase in wind speed increased leaf rust severity. The relationship was poorly explained by linear regression models as indicated by R^2 values 0.10 and 0.10, respectively on two varieties (G4 UOS-306 and G4 UOS-402).

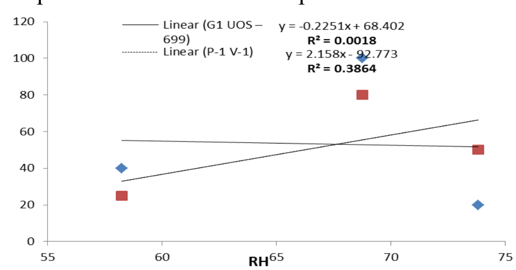
All the above mentioned results related to relationship between environmental factors have been presented in Fig 1.



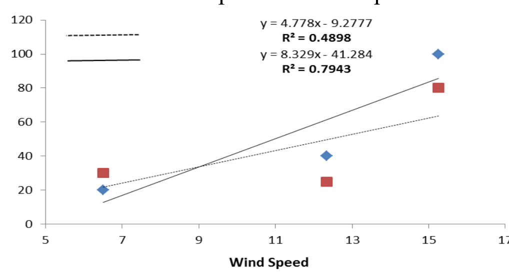
Stripe rust vs. maximum Temperature



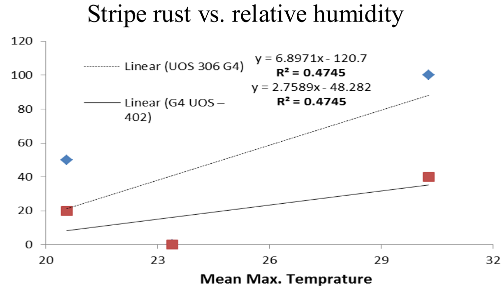
Minimum temperature vs stripe rust



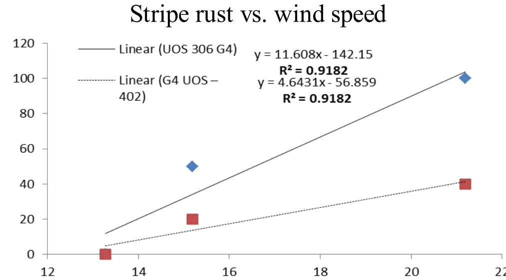
Stripe rust vs. relative humidity



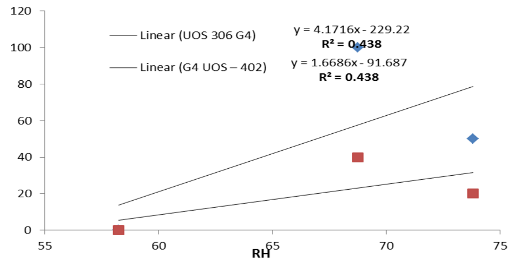
Stripe rust vs. wind speed



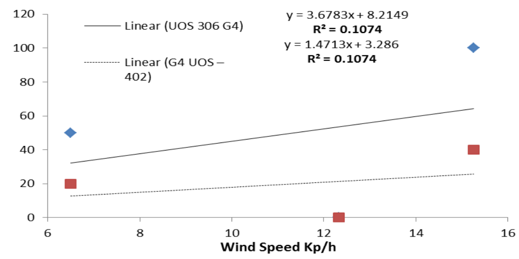
Leaf rust vs. maximum temperature



Leaf rust vs. minimum temperature



Leaf rust vs. relative humidity



Leaf rust vs. wind speed

Fig 1: Relationship between environmental factors

DISCUSSION

Rusts are the most important diseases of wheat. There are many methods to control rust diseases, but cultivation of resistant varieties is the most efficient. To evaluate the resistance of cultivars/varieties, screening method is commonly used. Screening method is most effective way to evaluate both phenotypic and genotypic characterization of wheat cultivars against rust diseases. This method also helps in developing segregating populations [12]. During current study, one hundred varieties/lines were sown and screened. After taking the three readings with an interval of week, the response of 97 varieties were rated against yellow and leaf rust.

The varieties showed more response to yellow rust as compared to brown rust. This may be due the effect of environmental conditions which favored the yellow rust more than leaf rust. This is in line with the previous researches[4, 5, 13, 14] conducted experiments to know the effect of environmental variables. Stepwise regression analysis was used to determine the effect of variables. Temperature (minimum and maximum), relative humidity, rainfall, wind movement were kept as independent variables, while disease severity of brown rust was kept as dependent variables. It was found that environmental effect was significant on brown rust. It was further found that due to change in environmental factors, disease severity also fluctuated while slow rusting response was found higher at 22-28°C maximum temperature, 8-16°C minimum temperature and at 70-80% relative humidity. Effect of environmental conditions on slow rusting reaction, was checked using linear regression models.[15]evaluated the resistance of wheat genotype Malviya-234 against stripe rust in relation to relative humidity, temperature and rainfall under field conditions. It was found that stripe rust appearance was more in last week of January than first week. It was further observed that when relative humidity, minimum temperature, rainfall conditions became conducive in 3rd week of February, infection of stripe rust increased exponentially. Similarly, when environment was sub-humid, stripe rust infection increased with the rise of temperature particularly with the rise of minimum temperature. They also found that relative humidity up to 98% favored the growth of unrediospore. Similar to our findings, it was also noted that high intensity of rainfall put negative effect on the germination of urediospore. A halt was observed in upsurge of rust during the months of March and April as a result of change in environmental conditions. [12]evaluated the resistance level of Kenyan wheat genotypes and checked the adult resistance in cultivars against brown and black rusts. They found that different cultivars behaved in a different way under various environments which support our results.

The present study experimental observations are in accordance with the results of [16]. They found that some varieties/lines which were susceptible in green house were found resistant in field. They attributed this due to three resistant genes present in those susceptible varieties. Many research workers observed difference in response of different varieties against rusts in green house and field conditions. They described it because of high inoculum pressure in experiment nursery studied the response of varieties against rusts of wheat under green house conditions and then cultivated under field conditions [4, 17]However, due to the appearance of new races, these varieties are always at the risk of infection. Inqlab-91 was high yielding variety in Pakistan and was also resistant to rusts. But now this variety is susceptible against stripe and brown rusts. The reason behind its susceptibility is appearance of new virulent races. Fungi have the ability to mutate and overcome resistant genes of the resistant cultivars [18].

In current research, some genotypes were immune or did not show symptoms. There may be two reasons behind their response. One possibility is that, either the inoculum of rusts might not have reached to these varieties. The other possibility may be the combine effect of major leaf rust or yellow rust resistant genes or combine effect of minor genes [16].

From the current research, it is advised that always that variety should be cultivated having major or minor resistant genes. Combine effect of major or minor genes produce durable partial resistance in cultivated rust resistant varieties. This is in agreement with the findings of [19]. Secondly, cultivation of same variety for longer time should be avoided. This can help in the suppression of new rust races. This argument is aligned with already conducted researches [20, 21, 22].

CONCLUSION

In present study, it was clear that genotypes were more prone to stripe rust than brown rust under Sargodha climate. The study further concluded that Sargodha climate favors more to stripe rust than brown rust. The varieties identified resistant during current study will help to identify resistant genes in these cultivars against stripe and brown rusts. Using current study information, the further studies may be designed to map stripe and brown rusts resistant genes in wheat cultivars.

REFERENCES

1. Rajaram S. (2001). Prospects and promise of wheat breeding in the 21ST century, Wheat in a Global Environment. Springer NL, pp. 37-52.
2. Zorb C, Ludewig U, Hawkesford MJ. (2018). Perspective on wheat yield and quality with reduced nitrogen supply. Trends Plant Sci; 23(11): 1029-1037.
3. Bálint AF, Kovács G, Sutka J. (2000). Origin and taxonomy of wheat in the light of recent research. Acta Agronomica Hung; 48(3); 301-313.
4. Grabow B. (2016). Environmental conditions associated with stripe rust and leaf rust epidemics in Kansas winter wheat(Doctoral dissertation, Kansas State University).
5. Afzal SN, Haque I, Ahmedani MS, Munir M, Firdous SS, Rauf A, Ahmad I, Rattu AR, Fayyaz, M. (2009). Resistance potential of wheat germplasm (*Triticum aestivum*L.) against stripe rust disease under rainfed climate of Pakistan. Pak J Bot; 41: 1463-1475.
6. Milus EA, Kristensen K, Hovmøller MS. (2009). Evidence for increased aggressiveness in a recent widespread strain of *Puccinia striiformis* f. sp. *tritici* causing stripe rust of wheat. Phytopathol; 99: 89-94.
7. Siwar C, Ahmed F, Begum RA.(2013). Climate change, agriculture and food security issues: Malaysian perspective. J Food Agric Environ; 11: 1118-1123.
8. Chakravarty B. (2011). Trends in mushroom cultivation and breeding. Aust J AgricEng; 2: 102-109.
9. Riaz A, Periyannan S, Aitken E, Hickey L. (2016). A rapid phenotyping method for adult plant resistance to leaf rust in wheat. Plant Methods; 12(1): 17.
10. Khan, M. A., Yaqub, M., & Nasir, M. A. (1998). Slow rusting response of wheat genotypes against *Pucciniarecondita* f. sp. *tritici* in relation to environmental conditions. Pak J Phytopathol; 10(2): 78-85.
11. FiglanS, Baloyi T A, Hlongoane T, Terefe T G, Shimelis H, Tsilo TJ. (2017). Adult plant resistance of selected Kenyan wheat cultivars to leaf rust and stem rust diseases.Cereal Res Commun;45(1):68–82.
12. Ali S, Shah SJA, Raman IKH, Maqbool K, Ullah W. (2009). Partial resistance to yellow rust in introduced winter wheat germplasm at the north of Pakistan. Aust J Crop Sci; 3, 37.
13. Raza W., Ghazanfar MU, Rehman AU, FayyazM. (2018). Screening of wheat germplasm against stripe rust disease under field conditions in Pakistan. Plant Prot; 2(03): 87-92.
14. Padmakar T, Mishra RS, Tomar SK, Tripathi P. (2001). Effect of climatic factors on stripe rust on wheat. Annals Plant ProtSci; 9(1): 154-155.
15. Ezzahiri B, Roelfs AP. (1989). Inheritance and expression of adult plant resistance to leaf rust in era wheat. Plant Dis; 73: 549-551.
16. Chaudhry MH, Hussain M, Shah JA. (1996). Wheat rust scenario, 1994-1995. Pak J Phytopathol;8: 96-100.
17. Prabhu KV, Luthra JK, Nayar SK. (1993). Slow rusting resistance in wheat (*Triticum aestivum*) to leaf rust (*Pucciniarecondita*) in northern hills of India. Indian JAgricSci; 63: 354-357.
18. Sharma S, Duveiller E, Karki CB, Thapa DB, Sharma RC, Joshi AK. (2015). Wheat stripe rust virulence and varietal resistance in the foot hill Himalayas of Nepal. JAgricSci Tec; 5, 477-485.
19. Hei NB. (2017). Evaluation of wheat cultivars for slow rusting resistance to leaf rust (*Puccinia trticina* Eriks) in Ethiopia. Afric J Plant Sci; 11(2): 23-29.
20. Pooja VS, Meenakshi R, Bunty S. (2017). Molecular characterization of diverse genotypes of Indian bread wheat (*Triticum aestivum* L. Em. Thell) by Using SSRs markers for leaf and stripe rust resistance. Annu Res Rev Biol; 2: 1-8.