IDENTIFICATION OF BROWN LEAF RUST *(PUCCINIA TRITICINA)* TOLERANT SPRING WHEAT GENOTYPES AND FAVOURABLE ENVIRONMENT SUPPORTING DISEASE INCIDENCE.

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A B S T R A C T

Leaf rust disease, caused by *Puccinia triticina*, is a major threat to wheat production in Pakistan, reducing the yield by up to 10% compared to other rust types such as stem and yellow rust. The disease severity varies depending on the plant's growth stage and susceptibility. Wheat is the most important and nutritious crop in Pakistan, due to its diverse growing conditions, climatic patterns and genomic features. The most effective and economical way to manage this disease is to breed resistant varieties. However, this is an ongoing process, as the pathogen can mutate and overcome the resistance of any variety. The experiment conducted in wheat research institute, Faisalabad, 250 wheat genotypes including commercial varieties, newly developed lines and land races were screened for brown rust consecutively in three years 2019-2020, 2020–21, and 2021–22, three varieties Arooj 2022, NARC Super 21, Dilkash 20 were symptomless and indicated high grain yield per plant. After comparing varieties, showing resistance against disease in the last three years While Pakistan-81 and Galaxy 13 were susceptible throughout this period. Moreover, after comparing environmental conditions favoring disease development in last three years it was observed that low temperature from 17 to 22°C, humidity above 80% and high rainfall increases the incidence of disease development.

KEYWORDS: WHEAT, BROWN RUST, ENVIRONMENT

Introduction

Agriculture is a vital sector for the economy and development of any country. It accounts for 25 percent of the total GDP and employs 48% of the labor force. Moreover, 70% of the population depends on agriculture directly or indirectly. Agriculture also generates foreign exchange and boosts other sectors. Wheat is the main food crop for most of the people in our country and 40% of the world's food is derived from wheat directly or indirectly (Anonymous, 2023). Wheat is a highly variable crop due to its diverse growing conditions, favorable climate patterns, and complex genome structure, which makes it a valuable and nutritious source of food. According to the FAO, the global supply and demand for wheat are balanced (FAO, 2023). However, the population growth rate is expected to reach 9 billion by 2025 (Chartres and Noble, 2015), which poses a challenge for ensuring food security. Therefore, increasing wheat production is a key objective for its economic and social importance. During 2022-23, wheat was cultivated at 9000 thousand hectares and production was 27.2 million tones. The share of wheat cultivation in Pakistan out of total crops is 10.1% and it contributes to 2.2% of the total GDP of the country. Due to the increase in the population of Pakistan, the requirement for food is increasing day by day. The country's population is growing at the rate of 2.4 percent annum. Therefore, the demand of wheat also increased in the future. According to projected data, in 2025, the requirement of wheat will be 31.415 million tones and the area of cultivation will be 9.050 million/ hectare. In 2030, its demand would increase up to 34.25 million tones having the same area under cultivation (PBS, 2023).

Wheat is a rabi crop that grows in the spring season in Punjab, Sindh, NWFP, and some parts of Balochistan. It also grows in the winter season in a few areas. Most of the wheat grown in Punjab is under irrigated area, while only 10% of it relies on rainfall. The wheat area in Punjab is 6.026,500. In Sindh, almost all the land is irrigated and the wheat area is 1,103,600. However, in Pakistan wheat production is low compared to other developed countries (PBS, 2023). Wheat faces many diseases such as rust (leaf, stripe and stem) smut, karnal bunt and powdery mildew that reduce its yield (Soliman, *et al*., 2012). One of the major problems for wheat is *Puccinia triticina*, which causes leaf rust. This fungus spreads through the air and can travel long distances and affect different regions. Brown leaf rust can reduce up to 10% of wheat yield. The other two types of rust, stem and yellow rust, are less damaging. The impact of leaf rust on wheat depends on the stage of plant development and the level of plant resistance. The favorable condition for rust to infect the plant is high relative humidity with a temperature range in 15-22°C with optimum temperature for spore's development is 20˚C in only 6–8 h for the development of disease. Leaf rust infections can cause yield losses beyond 50 per cent at even earlier stages. The damage to rust in leaves sometimes is less spectacular than that produced by strip (yellow), but as leaf rust frequently occurs the total yearly losses worldwide are likely more than the others. Pakistan lacks suitable varieties of wheat that can resist this disease and produce high yield (Hussain *et al*., 2006). In Western Australia, leaf rust caused a loss of 20 million dollars. In Pakistan, it caused a 10% yield loss in 1978 (Hassan 1979). Leaf rust can reduce the yield by up to 50% if it is very severe. Therefore, it is very important to develop new varieties of wheat that are resistant to leaf rust every year because it can overcome the resistance of any existing variety. An experiment was planned to screen rust tolerant wheat genotypes to select genetic potential and to understand which climatic and weather conditions are favorable for brown rust disease incidence.

Materials and method

The experiment was conducted at Wheat Research Institute, Faisalabad to find out the potential varieties showing resistance against leaf rust. In 2019-2020, 2020–21 and 2021–22, 250 wheat genotypes screened against brown leaf rust. Row to row distance maintained at 30 cm. The length of each line was 5 m. Morocco variety used as a natural source of inoculum and multiplication.

Weather data was recorded regularly to observe which temperature and humidity favors brown leaf rust incidence. Wheat genotypes sown early in October to find out the disease severity. All the agronomic practices kept same. Yield related traits including days to flowering, days to maturity, plant height (cm), number of grains per plant, 1000- grain weight (g) and grain yield per plant (g) recorded at maturity. Leaf rust reaction, symbol and field response given in Table 1.

Table 1. Leaf rust reaction, symbol and field response

Infection type	Host response	Symptoms
1	No disease	No Visible Infection
2	Moderately Resistant-Moderately Susceptible	Small Uredia present surrounded by necrotic area as well as medium uredia with no necrosis but possible some distinct chlorosis.
3	Moderately Susceptible-Susceptible	Medium uredia with some necrosis to chlorosis
4	Moderate Resistant	Small uredia present surrounded by
5	Resistant	Necrotic with or without minute uredia
6	Resistant-Moderate	Symptoms between resistant and moderate resistant
7	Resistant	moderate resistant
8	Tolerant Resistant Moderately	Uredia is present but no economic effect on plant
9	Susceptible	Medium uredia with no necrosis but possible some distinct chlorosis
10	Tolerant Susceptible	Large uredia is present but not enough to cause economic loss to plant
11	Tolerant Susceptible	Symptoms showing mix response in between susceptible and tolerant resistant

Results and discussion

The most suitable and environmentally benign method of controlling losses brought on by leaf rust is through genotypic resistance. Eight categories are created from the crop's overall reaction to analyze the disease's impact. The results of the wheat variety screenings conducted in 2019–2020, 2020–21, and 2021–22 against leaf rust varied. Three resistant types out of 250 showed the same reaction after three years. During this time, two cultivars, Galaxy-13 and Pakistan-81, were susceptible. Other types, however, had conflicting results. While other varieties showed a mixed response. The development of disease and sporulation are significantly influenced by temperature (Kolmer JA, 2005). The temperature, humidity, wind speed, and rainfall all affect the development of leaf rust since they have a significant impact on the urediniospore landing site and the disease's severity. Humidity, rainfall, and wind speed have positive correlations with the development of disease, while temperature has a negative link (Collard and Mackill, 2008). Prior to March, the combination of low temperature, humidity, and wind speed was not conducive to the development of disease. Urediniospores infected, multiplied, and spread more quickly during the first week of March because to favorable environmental factors such as low temperature, high humidity, and wind speed (Hussain *et al*., 1980). Thus, on March 4, brown rust spores were discovered in Morocco, and then Sahar-06.

Thus, to determine the environmental factors that promote urediniospore infection, three years' of average temperature and humidity data from mid-January to mid-April were compared (Brian, 2006). Following infection of urediniospores that were artificially inoculated, Arooj 2022, NARC Super 21, and Dilkash 20 shown resistance to leaf rust. Table 3 further showed that the tolerant varieties had good yields. Grain yield per plant was similarly impacted by Pakistan-81 and Galaxy 13, whose vulnerability to brown rust persisted throughout this time. In Pakistan, cultivating varieties to prevent leaf rust began in early October. Because of this, when urediniospores infect various varieties, plants reach their dough and maturity stage earlier. Thus, the losses brought on by an infection with urediniospores were decreased. When urediniospores produce infection, the flowering stage is most susceptible and results in a significant yield loss (Duplessis, *et al*., 2021).

However, environmental variables are also crucial in the development of disease. After analyzing three years of data, it is determined that temperature, humidity, and rainfall enhance the likelihood of contracting leaf rust (Schnurbusch, 2019). Rainfall and humidity have a positive link with leaf rust, but temperature has a negative correlation. Low temperatures (18–25°C) with high humidity are ideal for spore growth. A temperature above 80% and rainfall between 10 mm and more strongly encourages disease (Huerta-Espino *et al*., 2011) in Fig 1m Fig 2 and Fig 3. Because rust reduces wheat crop grain yield, pesticides usually used to prevent and treat disease incidence. However, the synthetic fungicide's chemical makeup has a worse impact on animal and human health and metabolism.

Additionally, it increases the disease resistance of single-quality wheat types. Researchers and field workers are finding that several strategies, such as cultivar susceptibility, variety genetic resistance, climatic interaction, microorganism disease transmission capacity, and field management process, are very helpful in mitigating the losses caused by leaf rust (Temesgen, 2015). Certain plants contain poisonous compounds called pathogens, which are extracted from the plant and applied to diseased plants.

For infection, urediniospores need six to eight hours of wetness (Dawn, 2008). Urediniospores can spread over continents; therefore, wind speed is also necessary for their long-distance transmission. The tolerant varieties can be used in hybridization program. Wheat should be grown from October 15 to October 30 to protect it from leaf rust. In Pakistan, urediniospore infections typically develop in mid-February to mid-March, during which time the plant is in its dough or maturity stage. According to Dubcovsky and Dvorak (2007), the impact of leaf rust on grain yield will be minimal. Following flowering, the plant focuses on producing grains, which are its primary use rather than being forage (Ahmad *et al*., 2010). Therefore, applying chemicals to treat leaf rust infections is a stupid idea because humans eat cereals, which can be fatal to them. As urediniospores mostly cause leaves to turn yellow and eventually die, which is excellent news for plant grain, no chemicals, water, or fertilizer should be applied during leaf rust infection after the flowering stage.

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Table 2. Three years response of tested verities Against Wheat Leaf Rust

No.	Varieties	2021–22	2020–21	2019–20
1	Arooj 2022	10R	5R	5R
2	NARC Super 21	5R	5R	10R
3	Dilkash-20	5R	10R	5R
4	Aas 2011	0	10R-MR	TR
5	Chakwal 86	5MRMS	20MS	5MR
6	9860	20MSS	60S	10MRMS
7	9846	30MSS	60S	5MSS
8	9864	10MRMS	60S	TR
9	9787	5MRMS	5R-MR	20MRMS
10	Manthar 2003	5MRMS	50S	TR
11	4-5IBSN	60MSS	80S	10MRMS
12	4-4IBSN	40S	60S	TR
13	5-7IBSN	5S	20MSS	5MSS
14	3-8IBSN	20MRMS	10MR	10MSS
15	116DN	20MSS	60S	15MSS
16	100DN	5MR	20MSS	15MSS
17	26-4IBSN	10MRMS	30S	TR
18	94-5IBSN	0	5R	10MSS
19	15-45IBSN	10MRMS	80S	0
20	74-5IBSN	10MSS	40S	10MSS
21	54-5IBSN	20MRMS	80S	5MSS
22	253-5EWYT	20MSS	30S	MR
23	263-5EWYT	5MRMS	30S	TR
24	AMIN-2008	5R	20MS	TR
25	Chenab 2000	10MRMS	80S	5MR
26	IMDAD 2005	20TR	5MR	5MSS
27	Barani 91	10MSS	60S	5MR
28	PB 85	5S-TR	10RMR	TR
29	FD 85	20S	10RMR	5MSS
30	Koh-e-nor-83	0	70S	5MSS
31	FD-83	5MRMS	5R	5MR
32	NASEER 2000	40S	20MSS	0
33	Shahkar 2011	10MRMS	60S	5MSS
34	PB-96	0	TR	0
35	Uqab 2000	30MSS	40MS	TR
36	AS-2002	0	60MSS	15MSS
37	Manthar 2003	TR	10MSS	20S
38	Sarsabaz	0	40S-TR	10MSS
39	AMIN-2008	0	TR	TR
40	Gold-16	5MRMS	60S-5R	5MR
41	Johar-16	5MRMS	60S-5R	5MR

42	AARI 2011	0	50S	5MR
43	RASKOH 2005	0	TR	TR
44	ZAM	0	TS	TR
45	PB-999	10MRMS	80S	5MR
46	Chakwal 97	20TR	5MR	5MSS
47	Bahawalpur 97	10MSS	60S	5MR
48	NARC 2009	10MRMS	60S	5MSS
49	Pakistan-81	40S	50S	10S
50	Galaxy 2013	40S	70S	10S

Table 3: Mean values of wheat genotypes of yield and yield related traits under normal and drought conditions

Genotypes	DOF m±S.E	DOM m±S.E	PH (cm) m±S.E	NOG P^{-1}	100 GW (g) m±S.E	GYP^{-1} (g) m±S.E
Arooj 2022	90±0.89	146.6±0.85	91.4±0.88	47.3±0.54	18.5±0.58	5.7±0.89
NARC Super 21	83.6±0.68	145.3±0.76	88.7±0.62	44.3±0.87	15.3±0.87	4.8±0.58
Dilkash-20	86.3±0.68	144.6±0.79	88.1±0.57	43.3±0.87	15.3±0.78	5.4±0.35
Pakistan-81	95.6±0.52	145.3±0.73	95.4±0.54	54.3±0.53	26.8±0.74	6.8±0.56
Galaxy 2013	94.6±0.53	149.6±0.71	95.2±0.54	53.3±0.87	25.5±0.86	6.7±0.56

Fig 1. Meteorological data recorded at Wheat Research Institute, Faisalabad, during the wheat crop season 2021-22.

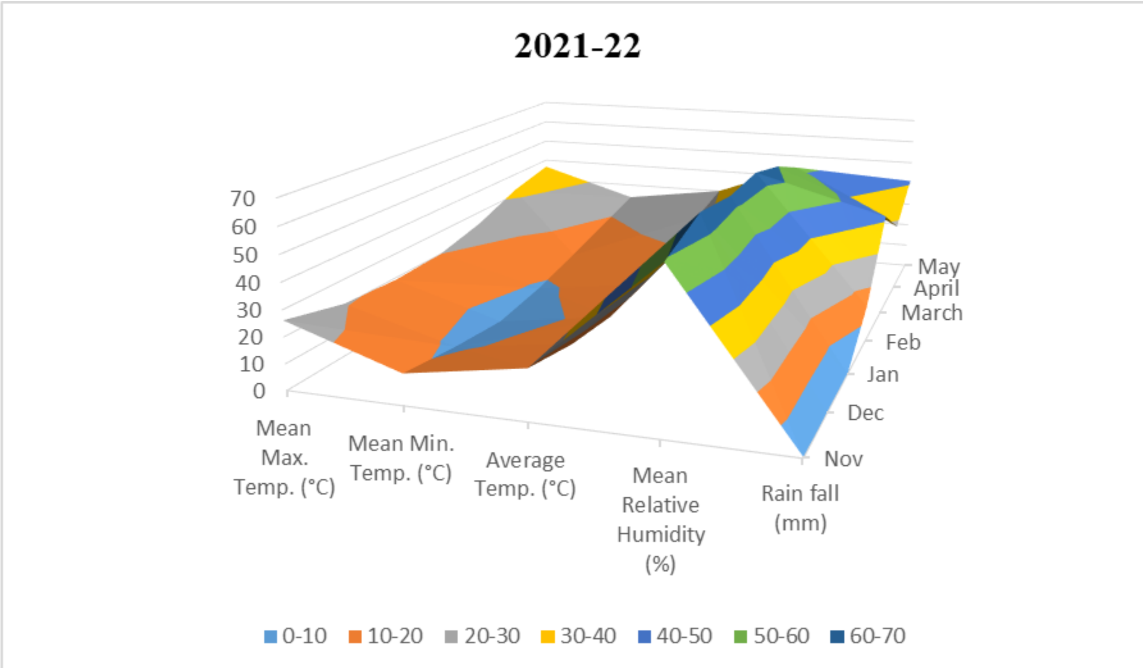

Fig 2. Meteorological data recorded at Wheat Research Institute, Faisalabad, during the wheat crop season 2020-21.

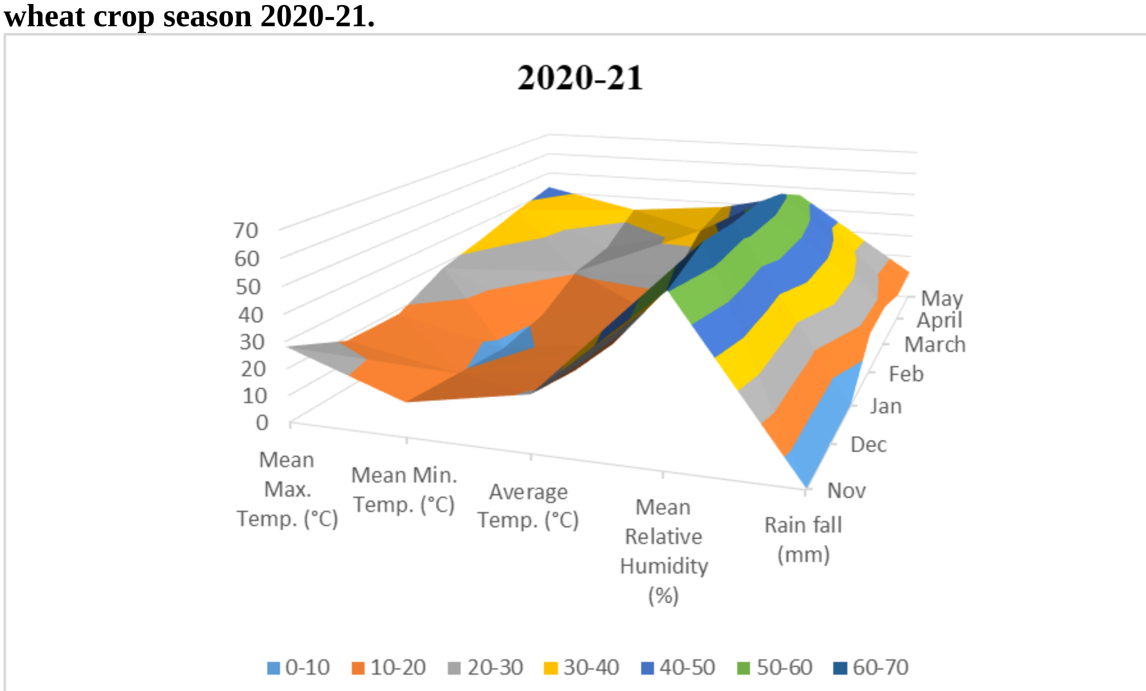

Fig 3. Meteorological data recorded at Wheat Research Institute, Faisalabad, during the wheat crop season 2019-20.