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SCREENING OF PAKISTANI WHEAT CULTIVARS FOR YIELD ATTRIBUTES AND RESISTANCE TO YELLOW RUST UNDER LOCAL ENVIRONMENTAL CONDITIONS OF DERA ISMAIL KHAN

Shazia Aftab[1], Samiya Sadiq[2], Noor Usman[*3]

[1,2, *3]*Crop Sciences Research Institute, National Agricultural Research Centre (NARC), Islamabad, Pakistan*

[1]Shaziaaftab311@gmail.com, [*3]noorusman1995@gmail.com

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Corresponding Author: *
Noor Usman

Abstract
Wheat (Triticum aestivum L.) is a staple crop and a fundamental component of global food security, serving as a major dietary source for the world's growing population. The introduction of semi-dwarf and high-yielding wheat varieties has significantly enhanced national production levels. However, changing climatic conditions demand the development of more resilient cultivars capable of tolerating disease, heat, and drought stresses.

This study aimed to evaluate elite Pakistani wheat cultivars for yield-related traits and resistance to yellow rust under the agro-climatic conditions of Dera Ismail Khan. Twenty-six cultivars were grown in a Randomized Complete Block Design (RCBD) with three replications. Data on days to 50% heading, plant height, spike length, 1000-grain weight (1000GW), and yellow rust response were statistically analyzed using the R package.

Results revealed that AZRC Dera exhibited the earliest heading (104 days), while Gulzar-19 was the shortest variety (68 cm) and Peer Sabaq-19 the tallest (100 cm). Spike length ranged from 8.8 cm (Faisalabad-2008) to 15 cm (NIFA Lalma-13). The highest 1000GW (65 g) was recorded for ARI-RK2022, whereas the lowest (40 g) was found in the rust-susceptible variety Faisalabad Punjab. Based on the yellow rust scoring scale, cultivars AZRC Dera, Khaista, Wadan, Akbar-19, Shahkar, and Gulzar-19 were classified as highly resistant (HR). Moderately resistant (MR) varieties included Hashim-08, Shahid-17, Fakhr-e-Bahakkar, and Tarnab Gandam; moderately susceptible (MS) was Shalimar-88; and highly susceptible (HS) cultivars included Faisalabad Punjab, Faisalabad-2008, and Punjab-1.

Overall, cultivars AZRC Dera, ARI-RK2022, and NIFA Lalma-13 demonstrated superior performance and are recommended for cultivation in the agro-climatic conditions of Dera Ismail Khan to enhance yield and disease resilience.

Introduction
The primary crop for feeding the planet's expanding population is wheat (*Triticum aestivum* L.), which is still a common ingredient in many cuisines. Around the world, it is grown on more than 220 million hectares, with an annual yield of more than 749 million tonnes. The tetraploid domesticated wheat *T. turgidum ssp. dicoccum*, which contributed the AA and BB sub-genomes, and the wild grass species *Aegilops tauschii*, which contributed the DD sub-genome, naturally hybridized to produce the hexaploid bread wheat (2n = 6x = 42, genome AABBDD (Peterson et al., 2006). Allohexaploid bread wheat (*Triticum aestivum L.)* is a species that resulted from two subsequent

rounds of hybridization. It is believed that the second hybridization event took place between 8000 and 10,000 years ago in the Fertile Crescent (Heun et al., 1997; Salamini et al., 2002). The size of the wheat genome is around 17 Gbps, and it is very complex, especially in terms of chromosomal duplications and rearrangements and the extremely high proportion of repetitive sequences (Akpinar et al., 2015)

The germplasm of bread wheat has thus changed throughout historic human migratory routes. From 8500 to 2300 years ago, the earliest farmers from this region carried it both westward to Europe and eastward to Asia, and domesticated wheat populations have spread over Europe and Asia, where they have adapted to local conditions to become known as landraces. The introduction of bread wheat to the New World began in the 16th century, first in Latin America, then in North America and Australia (Stevens et al., 2016). According to the experts, they were able to follow the evolution of wheat from the Fertile Crescent to the regions of Europe and Asia where it was planted and raised. caused a significant alteration in wheat that diminished its variety. According to their research, the majority of cultivars planted now are descended from strains that were created in southeastern Europe around the Mediterranean Sea and on the Iberian Peninsula. They point out that the lack of diversity creates a chance for further advancements in wheat production. Asian wheat varieties, they point out, are a good source of variation and may be utilized in the next research projects targeted at boosting crop yields as a result (Balfourier et al., 2019).

Wheat is the main staple food item of the country's population and the largest grain crop as well. Pakistan has been regularly importing wheat, except for a few years. Wheat's domestic production has remained short of its domestic demands. To estimate the wheat varietal effect on wheat production. The development of modern wheat varieties represents an advancement in agricultural science driven by the need for food security and crop resilience (Shiferaw et al., 2013; Abraham et al., 2014; Mondal et al., 2016). This process integrates traditional breeding techniques with cutting-edge genetic engineering to produce wheat that is more resistant to disease, pests, and environmental stresses. Modern varieties are designed to achieve higher yields, improved nutritional quality, and greater adaptability to changing climatic conditions. Through meticulous selection and hybridization, researchers can introduce desirable traits from diverse wheat lines, accelerating the creation of superior cultivars. This ongoing innovation not only boosts productivity but also ensures sustainable farming practices, contributing to the global effort to meet the dietary needs of a growing population (Razzaq et al., 2021; Singha and Sangha, 2024). The current study was designed to They point out that the Green Revolution

evaluate elite Pakistani wheat cultivars for yield-related traits and yellow rust resistance in the agro-climatic conditions of Dera Ismail Khan.

Materials & Methods

The current research was conducted in an experimental area of Gomal University, Dera Ismail Khan, in the wheat growing season from November 2023 to May 2024. **Research Design**

The research design for this study was standardized as RCBD (randomized complete block design) using three replications in the design. The experimental plot area was kept at 18 m × 5 m (90 m2) with 26 wheat germplasm replication^{-1} having a size of, each line being kept 5 meters in length and a 30 cm distance between lines. Sowing was carried out in lines, and ten seeds per row were dibbled, keeping a plant-to-plant distance of 15 cm and row-to-row distance standardized at 30 cm.

Practices

The land was prepared using 2-3 deep ploughings accompanied by rotavator operation. There was application of regular necessary agricultural practices such as fertilizer application of recommended doses of nitrogen and phosphorous, irrigation, hoeing etc.

Material

The germplasm comprising 26 wheat varieties was grown in the wheat growing season of 2022-2023 (Table 1). All 26 wheat varieties were acquired from the National Agriculture Research Council (NARC), Islamabad.

Statistical analysis

Table 1: Germplasm used in this study

S/No	Germplasm name	S/No	Germplasm name
1	Hashim-08	14	PS-15
2	AZRC Dera	15	PS-19
3	Khaista	16	Punjab-11
4	Wadan-17	17	Shalimar-88
5	Akbar-19	18	Zamindar-80
6	Akbar Punjab	19	Peersabaq-15
7	Shahkar	20	Peersabaq-19
8	Gulzar-19	21	Peersabaq-21
9	Shahid-17	22	Khyber-23
10	Peer Sabaq-13	23	Tarnab Gandam
11	Fakhre Bakkar	24	Taskeen-22
12	Faisalabad Punjab	25	NIFA Lalma-13
13	Faisalabad 2008	26	RK-2022

Data collection

Data was recorded keeping selection intensity at 5% from every line. The protocol for data collection of parameters is as under.

Parameters

1. Days to 50% heading

Days to 50% heading was documented from the time of sowing of the crop to the occasion of 50% heading in a specific line.

2. Yellow rust

The scoring method of leaf rust considered the percentage of leaf area covered by pustules on the most heavily infested leaves, using a scale from 0 to 100.

3. Plant height

Plant height was calculated by measuring the distance from the base of the main culm to the tip of the spike awn of the selected tiller.

4. Spike length (cm)

The spike length of the randomly chosen plants was calculated after measuring the spike from the base to the pinnacle of the spike, exclusive of awns and further analyzed for their average.

5. 1000-grain weight (g)

At the stage of physiological maturity, 1000 grains were calculated from the randomly selected plants and their weight was taken in grams.

The data collected for yield-related traits was subjected to the R package for graphical presentation.

Results & Discussion Days to 50% heading

Days to 50% heading is an important yield-related attribute which determines the early seed setting, early maturity and greater yield potential. Wheat

cultivars requiring maximum days to 50% heading face extreme terminal heat stress during anthesis and maturity, thereby experiencing late maturity and reduced yield, especially when late-sown or in heat stress-prone areas like Dera Ismail Khan. Modern breeding cultivars are developed for early maturity to bypass heat stress during the early stages of anthesis and maturity. Our results showed that all cultivars showed differences for days to 5-
% % heading. AZRC Dera was found to have the earliest heading (104 days) while Wadan-17 and Peer Sabaq-19 were found to be the late heading ones (116 days) as shown in Fig. 1. Our findings are supported by Nahar et al., (2010) who showed that in case of late seeding, the varieties phased a significant level of high-temperature stress that also significantly affected the required days to germination, booting, anthesis, maturity of all varieties including the yield as compared to normal sowing treatment. The temperature during the grain filling or grain maturing period in their trial was near 23°C in the case of normal seeding, and it was near 28°C to 30°C and sometimes reached above this range in the later period of late-seeded treatment. In the normal sowing treatment, the germination period was lower than the late sowing treatment, as during that time the temperature was higher as compared to the late sowing condition, where the temperature was lower. Days to anthesis and booting decreased due to late sown heat stress conditions, regardless of the cultivars. Thesephenological characteristics under heat-stressed significantly lower the grain yield as compared to normal conditions. Due to heat stress, the yield reduction was 69.53% in the wheat variety 'Sourav', 58.41% in 'Pradip', 73.01% in 'Sufi', 55.46% in 'Shatabdi' and 53.42% in 'Bijoy'.

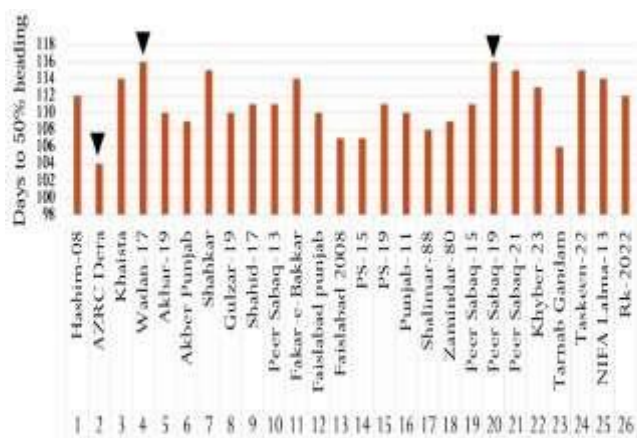

Fig. 1 Variations among germplasm for days to 50% heading. Black arrows show early and late-heading germplasm.

Resistance to yellow rust

Yellow/stripe rust of wheat, caused *by Puccinia striiformis* f. sp. *tritici* (Pst), is an important wheat foliar disease, mostly common in hot, humid wheat growing regions and causes heavy yield losses during epidemics. Severe infestation caused by yellow rust has been reported both in Pakistan (Ali et al., 2009) and elsewhere (Singh et al., 2004). In Pakistan, almost 70% of the acreage under wheat is Conditionsled thewheat cultivarsto Moderately prone to the disease. This biotroph reduces the total photosynthetic area, utilizes the plant's assimilates and interrupts with normal growth of the host, leading to a reduction in yield. Tremendous variations for yellow rust resistance were observed among all germplasm tested in this study. Yellow rust highly resistant (HR) cultivars include AZRC Dera, Khaista, Wadan, Akbar19, Shahkar, and Gulzar19. Moderately resistant cultivars (MR) include Hashim08, Shahid17, Fakhr-e- Bahakkar, and Tarnab Gandam. (MS) cultivars susceptible

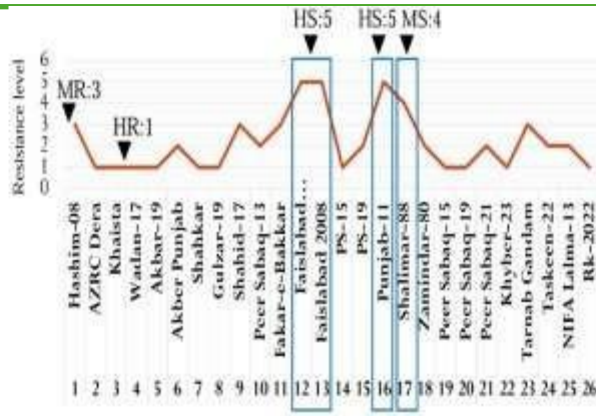

Fig. 2 Variations among germplasm for yellow rust resistance.

include Shalimar-88, while highly susceptible (HS) cultivars include Faisalabad Punjab, Faisalabad-2008, and Punjab-1, as shown in Fig. 2.

3. Plant height

No obvious differences were observed in height among cultivars, the reason being the exploitation of semi-dwarf nurseries of CIMMYT in wheat breeding programs in Pakistan. Gulzar-19 was a very dwarf variety (mean height: 68cm) while Peer Sabaq-19 was the tallest one (mean height: 100 cm) as shown in Fig. 3. Plant height is a significant trait influencing wheat yield due to its impact on lodging resistance and biomass accumulation. The height of wheat plants can vary widely among different varieties cultivated in Pakistan. Plant height is an important trait affecting wheat yield as it influences lodging resistance and biomass accumulation. Studies have shown significant variation in plant height among different wheat varieties. Taller varieties like 'Inqalab-91' and 'Punjab-96' have historically been popular due to their higher biomass production, which is useful for fodder. Varieties such as 'Seher-06' and 'NARC-2009' are known for their short stature, which enhances lodging resistance and is beneficial in regions prone to heavy winds and rain (Mumtaz et al., 2015).

4. Spike length

The grain yield of wheat is a variable trait that depends mainly on yield components and environmental factors. However, the variability of yield is more studied than yield components. The investigation of variability and components of phenotypic variance for plant height and spike length is very important for the cultivar creation in breeding programs. These two traits are quantitative characteristics which are in correlation with other yield components. Significant variations were found for spike length among all wheat varieties. Mean spike length ranged from 8.8 cm to 15 cm. The highest spike length was noted for NIFA Lalma-13 (15 cm) and the lowest for Faisalabad-2008 (8.8 cm). Our findings are supported by Zečević et al. (2008). They investigated genetic and phenotypic variability for plant height and spike length in ten winter wheat cultivars from different selection centres. The experiment was performed in a randomized block design in five replications on the experimental field in two years. A total of 50 plants have been analyzed in the full maturity stage. Average estimated values of plant height and spike length differed significantly among years and cultivars. The highest average value for plant height was Established at the Ljubičevka cultivar

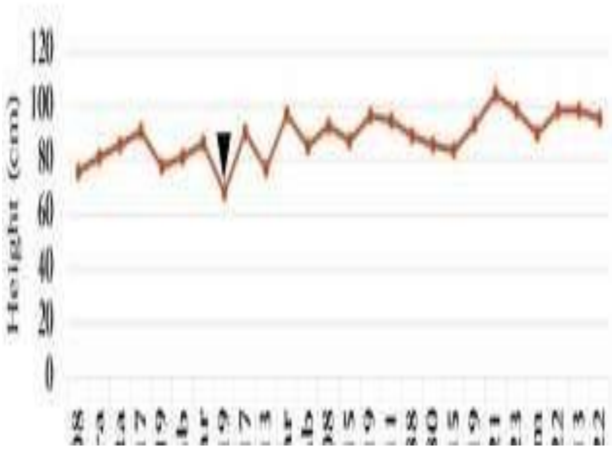

Fig. 3 Variations among germplasm for plant height.

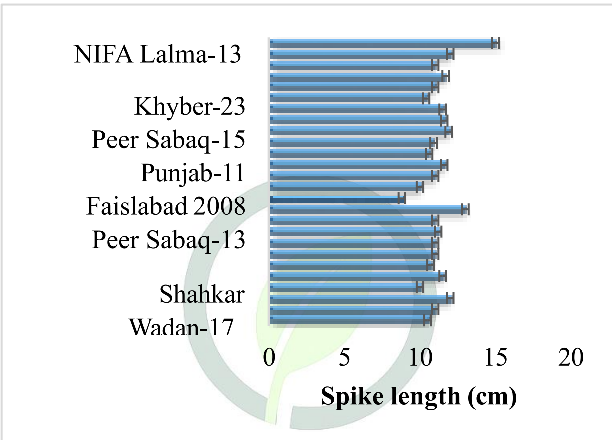

Fig. 4 Variations among germplasm for spike length.

(89cm), and the lowest average plant height was established at Zagrepčanka (64.0cm). Higher values were established in the second year than in the first year of investigation (69.1cm and 63.9cm, respectively). The variation coefficient of plant height for all examined cultivars and years varied from 2.7% to 6.1%. The highest average value for spike length was Ljubičevka (9.8cm), and the lowest was Slavonija (7.0cm).

1000GW

1000-grain weight (1000GW) is one of the most important determinants of wheat grain yield and is determined by grain length (GL), grain width (GW) and grain thickness. This quantitative trait is highly affected by environmental factors, especially when wheat germplasm is grown later than the normal time, which later experiences heat stress at the grain filling stage, thereby reducing the 1000- grain weight. In our study, the highest 1000GW was recorded for the recently developed variety of ARI- RK2022 (65g), followed by NIFA Lalma-13 (60g) while the lowest 1000GW was recorded for rust susceptible wheat variety Faisalabad Punjab (40g) as shown in Fig. 5. Our results are by Dhyani et al., (2013) who performed who evaluated wheat genotypes viz., DBW-140, Raj-3765, PBW-574, K-0-307 and HS-240 under timely/late sown and heat stress conditions for 1000GW and other yield-related traits. Their results showed that the heat susceptibility index (HIS) for 1,000-grain weight, grain weight and grain yield of wheat genotypes viz., HS 240 and K-0-307 was highest as compared with DBW 140, Raj 3765 and PBW 574 genotypes.

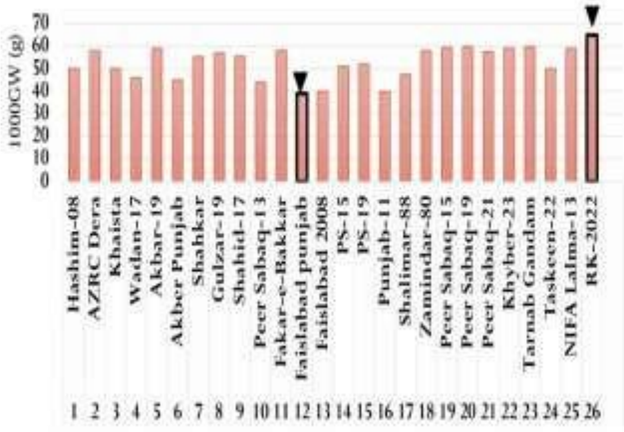

Fig. 5 Variations among germplasm for 1000GW. Black arrows show germplasm with the lowest and highest 1000GW. Conclusion & Recommendations

All 26 cultivars used in this study showed significant differences for different yield-related traits except plant height. AZRC Dera was found to have the earliest heading (104 days). Gulzar-19 was found to be the most dwarf variety (mean height 68cm) while Peer Sabaq-19 was the tallest one (mean height 100 cm). Mean spike length ranged from 8.8 cm to 15 cm. The highest spike length was noted for NIFA Lalma-13 (15 cm) and the lowest for Faisalabad-2008 (8.8 cm). The highest 1000GW was recorded for the recently developed variety of ARI-RK2022 (65g), while the lowest 1000GW was recorded for rust susceptible wheat variety Faisalabad Punjab (40g). Based on the yellow rust score scale, yellow rust highly resistant (HR) cultivars were AZRC Dera, Khaista, Wadan, Akbar19, Shahkar, and Gulzar19. Moderately resistant cultivars (MR) include Hashim08, Shahid17, Fakhr-e-Bahakkar, and Tarnab Gandam. Moderately susceptible (MS) cultivars include Shalimar-88, while highly susceptible (HS) cultivars were Faisalabad Punjab, Faisalabad-2008, and Punjab-1. Based on the findings of this study, AZRC Dera, RK2022 and NIFA Lalma-13 are recommended to be grown by the local farmers in the agro-climatic conditions of Dera Ismail Khan.

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