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Original Research Article

JAU-21: A NOVEL HIGH YIELDING AND DISEASE RESISTANT SIX-ROWED BARLEY VARIETY FOR RAINFED AND IRRIGATED AREAS OF PUNJAB, PAKISTAN

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Abstract *The rise of sustainable barley production dictates the development of new barley varieties with enhanced yield and resistance to biotic and abiotic stresses. WRI, AARI, Faisalabad, Pakistan has released several barley varieties together with JAU-21 since its formation. Jau-21 is a six-row barley variety that can grow and ripen in a shorter time was selected from the international nursery GSBSN received from the International Center for Agriculture Research and Dry-land Area, Egypt during 2014-15. The revealed genotype with variety code B-15018 was further appraised in preliminary and regular during 2015-17 which super seated 21.65% than Haider-93 check on average bases. In the Punjab uniform barley yield trial, the proposed line outclassed the same check varieties by 20.29% over different settings of Punjab in 2017-18. It was further tested for yield and disease constancy in the national uniform barley yield trial, it excelled at 10.31 and 4.46 % over Haider-93 and Sultan-17, respectively during 2018-19 and 14.66 and 9.93% over Jau-87 and Jau-17, respectively in 2019-20 %. It can tolerate rust by displaying disease reactions from 0 to traces rather than 100 MS over check. Agronomic judgments and quantitative and qualitative analyses were also performed during 2017-18 to 2019-20. Due to its bold grain, auspicious yield performance, and appealing rust resistance trait over multi-location, the Punjab Seed Council approved B-15018 in 2021 with the name "Jau-21" for general cultivation in irrigated and rainfed areas of Punjab, Pakistan.*

Keywords: *Six-rowed; disease resistant; rainfed, irrigated; barley variety; Punjab*

Introduction

Barley (*Hordeum vulgare* L.) is a speedily mounting cereal that can increase soil fertility by using as fodder and as a cover crop (Ghanbari et al., 2012). Hierarchically barley stood fourth in quantity produced and cultivated area in the world after maize, wheat, and rice (Kılıç et al., 2010). Historically it has permitted itself as the first cultivated grain globally. Its grains are a rich source of macro and micronutrients including vitamins, calcium, and iron, and are used as food for humans and animals as well as in the brewing and malt industry. Greater content of soluble fibres called beta-glucans has been found in barley in contrast with other cereal grains (Ali et al., 2013; Rasheed and Malik, 2022; REHMAN et al., 2020; Shah et al., 2017).

In Pakistan, barley area and yield are constantly declining which fallouts in low production, and for its import adequate amount of foreign exchange has to be paid. During 2016-17, a negative growth of 9.8 percent of barley was documented due to a decline in the area (Anonymous 2016-17). Diminution in yield is the key focus of breeders and expanding the yield recital, especially under water stress conditions is their major objective (Pakniyat, 2010). Barley *Hordeum vulgare* L.) Although, it is an abiotic stress-tolerant crop in comparison with other crops yet drought, salinity, sodicity, acidity, water logging, and heat affect its production and productivity (ALI, 2022; BASHIR et al., 2023; Fatima et al., 2023; Rani et al., 2018). However, (Alghabari et al., 2015) testified that the major factors decreasing crop production and development are stresses of heat, drought, and diseases. Reduced grain expansion by drought stress during stem elongation and grain filling stage was perceived which eventually affects the barley yield (Alghabari and Ihsan, 2018; Ali et al., 2016). An optimum number of plants and spikes per unit area and escape from water stress of the early-planted barley are reasons of yield improvement.

The proposed variety is six-rowed barley having higher grain protein content than the two-row barley. This newly developed line can grow and ripen in a shorter time than any other cereal. Due to the rapid climatic shift, there is a dire need to develop drought-tolerant crops in agriculture. This barley line has been developed for water stress and irrigated

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areas use expressively less water than old commercial varieties. This line was tested under rainfed conditions and the best results were accomplished in both irrigated and rainfed yield trials conducted at many locations. This line has bold grains and better quality traits than the check variety Haider-93 which also goes under its recognition to be approved as a commercial variety.

Materials & methods

Jau-21 is a novel barley genotype that is suggested for rainfed areas and also for irrigated areas of Punjab, Pakistan. The variety has parentage of Cr115 / Pro // Bc /3/ APi/ CM67 /4/ Giza120 /5/ Sutter*2/ Numar /6/ Arar / Rhn-04 and with a pedigree of ICB98-0421-0AP-15AP-0AP-10AP-0AP-1AP-0AP and was selected from international nursery GSBSN from ICARDA, Egypt during 2014-15. The stated genotype was designated due to capable yield concert and resistance against rusts. The candidate barley line with a six-rowed head type was promoted to station yield trials with code B-15018 grain yield performance assessment. This trial was conducted in a randomized complete block design with three replications and a plot size of 6 rows of 5m length with 30 cm row-to-row distance (Peterson et al., 1948).

This line was further tested in a regular yield trial (B-trial) upon performing better than check Haider-93 during 2016-17. The preliminary and regular yield trials were carried out at the Wheat Research Institute, Faisalabad, Pakistan. Based on a good performance, it was tested in Punjab uniform barley yield trial in different districts of Punjab against check Haider-93 to check yield potential and acclimatization throughout Punjab province during the year 2017-18. Keeping in view the performance of yield, this candidate line was tested in national uniform barley yield trials for continuously two years (2018-19 and 2019-20). The disease screening of this candidate line was conducted at seven locations during 2017-18 to 2018-19. Rust scoring was done by using Cobb scales (Committee, 2000). This imminent line was also assessed in sowing dates trial and quality traits analysis in cereal technology, laboratory by following the standards described by the American Association of Cereal Chemists (Anon, 2000) and the International Association for Cereal Science and Technology (AHMAD et al., 2022). A brief description of the developmental history of Jau-21 is given in Fig. 1.

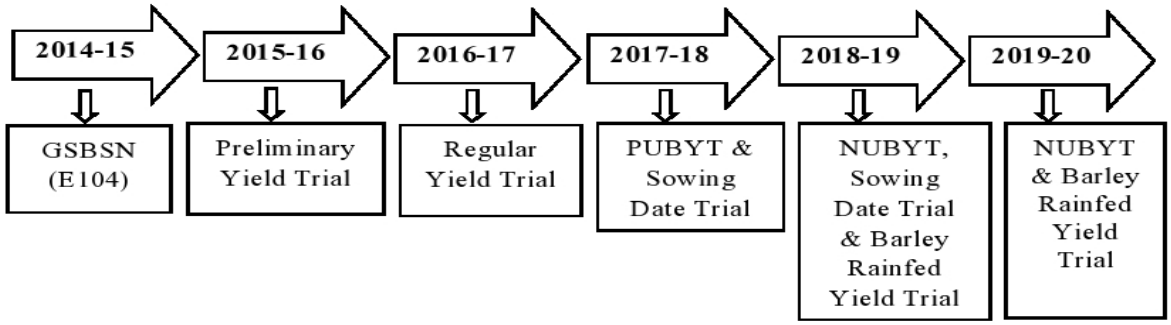

Fig 1. Time line description of B-15018

Result and discussion

Station yield trials (2015-16 TO 2016-17)

Station yield trial consisted preliminary yield trial (A trial) and a regular yield trial (B trial) which were conducted at WRI, Faisalabad in 2015-16 and 2016-17, respectively. The advanced line (B-15018) yielded 13.5 and 30.0% more than check (Haider-93) in the A trial and B trial, respectively (Table 1). Similar results were found by (Ladoui et al., 2020).

Provincial uniform barley yield trial (PUBYT)

Due to its good performance it further promoted to Punjab uniform barley yield trial for wider adaptability testing B-15018 also delivered great in PUBYT during 2017-18. It was tested at five locations and produced 20.29 % more yield than the same check (Table 1). Our findings are in line with (Banterng et al., 2006). This added yield production than check made it involved additional testing in NUBYT for wider adaptability and yield steadiness throughout Pakistan.

Table 1. Yield Performance of Barley Variety "B-15018" in A-trials, B-trials, normal, rainfed and PUBYT

Sr. No.	Type of trial and Year	Yield (kg ha^{-1})	
		B-15018	**Haider-93**
1	A-Trial (2015-16)	2793	2461
% increase over check		**13.49**	**-**
2	B-trial (2016-17)	3117	2397

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% increase over check		**30.03**	-
3	Normal (2018-19)	4522	3318
4	Rainfed (2018-19)	4384	3258
Average yield		4453	3288
% increase over normal		**3.14**	1.84
5	Normal (2019-20)	4332	3303
6	Rainfed (2019-20)	4193	3267
Average yield		4263	3285
% increase over normal		**3.21**	**1.10**
7	PUBYT (2017-18)	B-15018	Haider-93
Locations	a)-Wheat Research Institute, Faisalabad	3689	2238
	B)-Govt Seed Farm, Dhakar, Pakpattan	3200	2619
	C)-Maize and Millets Research Institute Sahiwal	4002	3471
	D)-Adaptive Research Farm, Gujranwala	2659	2264
	Rice Research Institute, Kala Shah Kaku	3668	3720
Average yield		3444	2863
% increase over check		**20.29**	-

National uniform barley yield trial (NUBYT)

Analyzing newly developed lines with commercial checks in diverse testing environments, where the reactions would redirect the adaptability of the genotypes to the inherent traits delivers valuable evidence for advanced line selection and final release (Gatto et al., 2021). Therefore, a genotype needs to accomplish steadiness in diverse settings over the years where it shows strong throughput. In the same theme, the candidate line was tested over four different locations in Pakistan to gauge its broader malleability for yield and resistance. The Candidate line B-15018 excelled over check variety 10.31 and 4.46 % over Haider-93 and Sultan-17, respectively during 2018-19 and 14.66 and 9.93% over Jau-87 and Jau-17, respectively in 2019-20 (table 2). This evidence signposts that the marked reduction percentage in new varieties (Jau-17 and Sultan-17) is less than old varieties (Haider-93 and Jau-83) over B-15018. This increasing percentage of genetic homogeneity among modern and new cultivars was also normally stated (Shrestha and Lindsey, 2019).

Table 2. Yield Performance of "B-14035" in NUBYT during 2018-19 and 2019-20

Sr. No.	Locations	NUBYT (2018-19)			NUBYT (2019-20)		
		B-15018	Haider-93	Sultan-17	B-15018	Jau-87	Jau-17
1	Wheat Research Institute, Faisalabad	3711	3239	3647	3993	3678	3718
2	Govt. Seed Farm Dhakkar, Pakpattan	3713	3609	3596	3820	3382	3515
3	Agriculture Research Institute, D.I.Khan	2666	2341	2465	2397	1975	2010
4	QAARI, Larkana	1380	1209	1272	1986	1604	1851
Average (kg ha^{-1})		2867.5	2599.5	2745.0	3049	2659.8	2773.5
% increase over checks		**-**	**10.31**	**4.46**	**-**	**14.66**	**9.93**

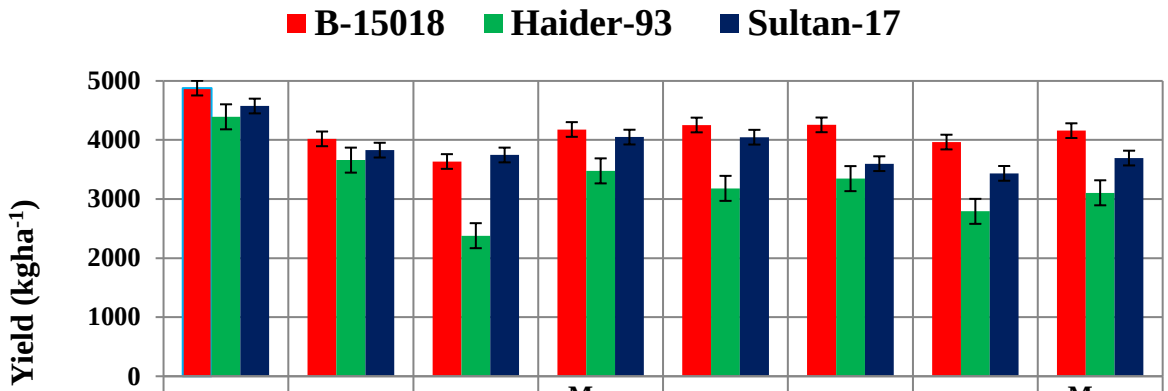
Agronomical trial

The grain yield of malting barley (*Hordeum vulgare* L.) can be maximized by good agronomic management while meeting quality standards (Zulkiffal et al., 2022). Secondly, grain weight is significantly subjected to shifting sowing dates because it is a complex quantitative trait. The sowing date trial was conducted to fulfill this requisite and to disclose the sowing time fitness for the newly established barley line under a climatic change situation.

The experiment was sown on three dates with fortnightly pauses starting from 5th November to 5th December 2017-2018 and 2018-19. On an average basis, advanced line B-15018 in sowing date trials produced 20.2 and 3.2 % more grain yield during 2017-18 while in 2018-19 percent increase in yield was 33.9 and 12.6 over check Haider-93 and Sultan-17, respectively.

In all sowing date trials, D_1 (4878 kg hac^{-1}) was found more yielder in 2017-18 while D_1 (4254 kg hac^{-1}) and D_2 (4256 kg hac^{-1}) were at par in the next year for an advanced line to get maximum grain yield (figure 2). (Singh et al., 2005) also recognized high-yielding and highly stable wheat candidate lines over eight different sowing dates were also by using parametric stability models. Early sown crop (1st

week of Nov) gave more yield as compared to crop sown after 15 days of interval during 2017-18. The optimum date of sowing is necessary for the maximum possible yield. The grain yield of barley is decreased by delay in planting (Carter et al., 2019).



	D1	D2	D3	Mean 2017-18	D1	D2	D3	Mean 2018-19
B-15018	4878	4019	3636	4178	4254	4256	3965	4158
Haider-93	4392	3659	2380	3477	3181	3346	2792	3106
Sultan-17	4575	3828	3746	4049	4047	3599	3435	3694

Fig 2 B-15018 yield (kg hac^{-1}) display in sowing dates trials of barley during 2017-18 and 2018-19

Rainfed yield trial

The yield performance of barley line B-15018 was also examined by withholding the applied water till maturity for two cropping years during 2018-19 and 2019-20 to recognize the drought-tolerant genotypes under natural circumstances of rainfed conditions. These data suggest that the differences among cultivars in grain yield were more expressed under the natural conditions in the field. Data showed that the proposed line under water stress conditions was comparable to normal irrigation to checks given in Table 1. The variety showed its potential in such conditions by producing more yield against local check Haider-93 and Jau-17**.** At par yield potential with normal sowing indicated that variety has the potential to cope with drought stress. Anonymous 1994 exposed that the varieties developed for low water conditions had better grain yield and test weight than varieties bred for high water use conditions.

Disease screening studies

The pathological study was led for two years 2017-18 to 2018-19 for screening against leaf and yellow rust in a local disease screening nursery. Rust recording was carried out by using a modified Cobb scale [10]. During 2017-18, Ieaf rust was noted as 10MR, TS, TMR, and TR in Pirsabak, Peshawar, Islamabad, and Faisalabad, correspondingly while it was zero in other locations (Khanewal, Bahawalpur, and Kotnana) Likewise yellow rust seemed as TR, TS and TMR at Pirsabak, Peshawar and Kotnana, respectively while it was zero on other locations (Faisalabad, Bahawalpur, Khanewal and Islamabad) on B-14035.

During 2018-19, Ieaf rust was recorded as, TMS, 5MR, TR, and TS in Islamabad, Peshawar, Pirsabak, and Faisalabad while it was zero in other locations (Kotnana, Bahawalpur, and Khanewal) Similarly yellow rust appeared in TMR, TR TMS and TR at Islamabad, Peshawar Pirsabak, Bahawalpur, respectively while it was zero on other locations (Faisalabad, Kotnana, and Khanewal) on B-14035. In two defined years disease reactions together, diseases varied from 0-100MS on check variety (Haider-93) in above mention locations.

Qualitative and Quantitative traits

Uniform line B-15018 is approved as Jau-21 due to its high yield potential and genetic diversity and replaces the existing commercial variety, Haider-93 which dominates major barley growing areas and currently has become susceptible to different rust races throughout the country. To fulfill the requirements of the Punjab Seed Council for variety approval, quality traits analysis was also performed by using approved methods of the American Association of Cereal Chemists (Sönmez, 2021). Jau-21 was found better for its quality traits. (Yüksel et al., 2017) analyzed protein content and 1000 kernel weight of barley in the range of 10.05-12.75% and 35.5-40.69 g which were at par with our results. However, (Öztürk et al., 2014) found plant height in the high range of 93-130 cm in barley Whereas B-

15018 has a range of 102-110 cm (table 3). which is less subjected to logging (Tabassum et al., 2021) reported that plant height is a substantial component in relations of resistance to the lodging of barley. Parallel findings were observed by (Qasim et al., 2022) regarding days to heading, maturity, growth habit, straw, and seed color except anthocyanin pigmentation which was weak in his finding

Table 3. Qualitative and Quantitative traits range of B-15018

Quantitative traits	Range	Qualitative traits	Range
Plant height (cm)	102-110	Growth habit	Semi erect
1000 Kernel weight (g)	34-40	Coleoptile	White
Protein contents (%)	10.9 -13.3	Anthocyanin	Absent
Flag leaf area (cm)	18-25 x 1.5-2.1	Flag leaf attitude	Semi erect
Rachis-segments & length (cm)	14 & 6	Stem color	Green
Stem diameter (mm)	6.1-6.4	Stem waxiness	week
Days to heading	98-102	Seed color	Amber
Days to maturity	124-145	Seed surface	Opaque
Productive tillers/m2	146-148	Straw color	Yellowish white

Conclusion

Jau-21 is a higher-yielding variety than previous barley varieties like Haider-93, Jau 87, Jau 17, and Sultan 17. Barley cultivators have desired the replacement of old cultivars for domestic usage. It is highly resistant to leaf and yellow rust. Jau-21 has wider adaptability for different ecological zones. It can tolerate drought stress. Punjab Seed Council has approved its cultivation throughout Punjab due to its promising yield performance. This newly developed variety will be a good addition to commercial varieties of this region.

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Declaration

Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

The study was approved by authors.

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Conflict of Interest

There is no conflict of interest among the authors regarding this case study.

Authors Contribution

All authors contributed equally.

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