JAU-17: A FIRST HIGH YIELDING AND MALTING BARLEY VARIETY SUITABLE FOR MARGINAL LANDS OF PUNJAB

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ABSTRACT
Wheat Research Institute, Faisalabad, Pakistan developed the ever first variety of barley as Jau-17 in Pakistan. Barley variety performed best in a series of irrigated and rainfed yield trials conducted at Wheat Research Institute, Faisalabad and outstation yield trials throughout the Punjab province during 2008-2019. In the yield trials for three consecutive years from Preliminary to Regular and Advanced Yield Trials, it had out-yielded the check variety Haider-93 by an average of 23.34% while in outstation yield trials throughout the Punjab province, it produced 11.40% higher grain yield than commercial check variety Haider-93. Jau-17 had medium to tall stature of about 99 to 110 cm length, growth habit was semi erect and had medium-length-awned ear which had yellowish white color. It took 90 to 100 days to complete heading and matured in 140 to 145 days with tillering capacity (154-160 per m²). The seed is amber in color with 1000-grain weight of upto 42 gram. For quality trait evaluation it had good quantity for protein (12 to 13.7%) and test weight (52.7 to 58 kg/hl) along with opaque seed surface. Its malt making quality was excellent for industrial uses. In 2019 Jau-17 was approved by Punjab Seed Council for general cultivation due to its superior performance over the years for better grain yield, resistance against rusts and nutrition quality.

KEYWORDS: Hordeum vulgare; moisture stress tolerance; beverage; two-rowed; malting; marginal land; yield; Pakistan.

INTRODUCTION
Barley (Hordeum vulgare L.) is the oldest and most widespread cereal grain. It is mostly grown in rainfed areas of Punjab, Balochistan and KPK provinces due to its higher capacity to tolerate unfavorable climatic conditions like drought, salt, heat etc. So, there is a scope for its popularization in irrigated areas also where limited water is available for irrigation. Various environmental and natural processes like spontaneous mutation and selection had contributed wider genetic diversity to barley that enhances its adaptability to adverse environmental conditions (Kumar et al., 2020). According to IPCC (2007), the global surface temperature would rise by 1.8 to 4.0°C during 21st century and world rainfall systems would alter extensively. Decrease in yield with time is the foremost apprehension of plant breeders and they accentuate on yield improvement under less water environment (Nazari and Pakniyat, 2010; Zare, 2012; Anwar et al., 2019). Ajalli and Salehi (2013); Ashraf (2010) described drought tolerance in crops is the most multifaceted feature to appreciate. Yield is linked with varying ecological situation mainly wetness accessibility in soil that affects the development of the crop plants and relations with cultivars (Karami et al., 2005; Chapman et al., 2012; Karamanos et al., 2012; Abdullah et al., 2021). Furthermore, in Pakistan barley production has declined resulting in spending large amount of foreign exchange on its import. Beverage industry in Pakistan requires good malting quality of 2-rowed barley varieties for the production of better quality products. Unluckily in Pakistan proper attention has not been given in the past for the development of good quality 2-rowed barley varieties. The barley varieties released in the past are 6-row type and are not suitable for industrial purposes. The advanced line B-09008 (Jau-17) has performed best in a series of irrigated and rainfed yield trials conducted at Wheat Research Institute, Faisalabad as well as outstation yield trials. The proposed variety is 2-rowed type, good yielding, lodging resistant , moisture stress tolerant, bearing bold grains and other desirable grain quality
attributes. Therefore, is suitable to be retained as commercial variety. Barley has wider adaptability world wide but data showed decreasing trend during last decade at international level (Petcu et al., 2019). In view of above, current study was conduct to check the performance of Jau-17 for marginal lands of Punjab.

MATERIALS AND METHODS
Current study was conducted at Wheat Research Institute, Ayub Agricultural Research Institute, Faisalabad, Pakistan during 2008 to 2019. A new barley genotype “EGIA/LAUREL’S’//ALELI/3/ARTA” included in the nursery of International Barley Crossing Block (IBCB) received from International Center for Agricultural Research in the Dry Areas (ICARDA), Beirut, Lebanon was sown during 2008-09. Its phenotypic performance and yield attributes made a pathway inclusion in station yield trials under the code name B-09008 for evaluating yield and yield related traits against commercial check variety Haider-93 during 2009-10. The entry was tested in Preliminary Yield Trial (A,B -Trial) which was laid out in Randomized Complete Block Design in triplicate while individual plot size was set at 6 m² (4 rows, 30 cm apart, 5m in length). The entry B-09008 produced higher grain yield than commercial check variety and it was promoted to Regular Barley Yield Trial (B-Trial) and later to Advanced Yield Trial (C-Trial) during 2010-11 and 2011-12, respectively. The site for conducting these trials was field area of Wheat Research Institute (WRI), Faisalabad, Pakistan. In Out-station Yield Trials it was tested throughout the Punjab province during 2012-13, 2013-14, 2015-16, and 2016-17 in Punjab Uniform Barley Yield trial for four years. This testing provided information related to wider adaptability & yield stability in different locations throughout Punjab province against common commercial check variety Haider-93 for comparison. This entry was also undergone standard disease screening experiments against local rusts from 2014-15 to 2015-16 in different ecological zones of the country. For three consecutive years from 2014-15, 2015-16 and 2016-17, B-9008 was also tested in rainfed conditions. To determine quality traits, the parameters were estimated at Wheat Research Institute, Faisalabad from seed samples of PUBYT trials under the standard procedures set by American Association of Cereal Chemists (Anon, 2000) and International Association for Cereal Science and Technology (Anon, 1994). The developmental history in brief is presented in Table 1.

RESULTS AND DISCUSSION
Station yield trials
This entry B-09008 was tested in preliminary, regular and advanced yield trials (BA, BB & BC) for three consecutive years in station yield trials during 2009-10, 2010-11 and 2011-12. During preliminary yield trial, it tested against sixteen (16) entries trial in triplicate and compared with local check variety Haider-93 in field area of WRI, Faisalabad during 2009-10 (Table 2). It produced 9.2% higher grain yield than commercial check variety Haider-93. It was promoted to Regular Barley Yield Trial (B-Trial) and later to Advanced Yield Trial (C-Trial) during 2010-11 and 2011-12, respectively, where it produced 13.0% and 8.5% higher grain yield than Haider-93. Similar results were reported by Abdullah et al. (2021).

Provincial uniform yield trial
After producing 23.34% higher grain yield than commercial check variety in Station Yield Trials, the advanced line B-09008 selected for out-station yield

| Sr. No. | Year     | Trial          | Yield (kg/ha) | Percent increase over check |
|--------|----------|----------------|---------------|-----------------------------|
|        |          |                | B-09008       | Haider-93                   |
| 1      | 2009-10  | A-Trial        | 3278          | 3002                        | 9.2                        |
| 2      | 2010-11  | B- Trial       | 2486          | 2200                        | 13.0                       |
| 3      | 2011-12  | C- Trial       | 2442          | 2250                        | 8.5                        |
|        |          | Average yield  | 2735          | 2484                        | 10.10                      |

Table 1. Development history of B-09008

Table 2. Yield performance of “B-09008” in station yield trials
trials throughout the Punjab province for four years and again it out yielded the check variety Haider-93 by 12.07, 6.13, 2.6 and 23.34%, respectively (Table 3). Results are in line with Abdullah et al. (2021) and Boudiar et al. (2020).

**Rainfed yield trials**

The performance of B-09008 was also tested in Rainfed Yield Trial for consecutive two years (2015-16 to 2016-17) to check its performance in water scarce localities where it produced marvellous results against commercial check variety Haider-93. On overall mean basis it produced 14.86% higher grain yield than check variety (Table 4). These results coincide with the findings of Subhani et al. (2015) where B-09008 produced best grain yield as compared to all other entries in water stress conditions. Studies of Tokhetova et al. (2020) also found that hull-less barley varieties had higher adaptability to stress environmental conditions particularly water stress. Similarly, studies of Boudiar et al. (2020) showed various barley morphological traits (root and shoot) that contribute tolerance of barley in water stress conditions.

**Disease screening studies**

This new genotype was screened for determining response against incidence of yellow and leaf rust in Local disease screening nursery (LDSN) at multiple locations (Bahawalpur, Khanewal, Faisalabad, Islamabad, Pirsabak, Peshawar) for two years from 2014-15 and 2015-16. The advanced line did not show any sign of yellow and leaf rust incidence and could be considered as rust tolerant barley variety. These results justify its field adaptation in such a shifting climatic condition and hence it would very important for further use in different barley breeding programs (Table 5). Similar results were confirmed by Abdullah et al. (2021).

**Quality parameters**

Different quality attributes were tested for this proposed variety B-09008 against other advanced lines and

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**Table 3. Yield performance of “B-09008” in provincial uniform yield trials during 2012-13 to 2016-17**

| Sr. No. | Location                                           | B-09008 | Haider-93 |
|---------|----------------------------------------------------|---------|-----------|
| 1       | Wheat Research Institute, Faisalabad               | 4154    | 3211      |
| 2       | Rice Research Station, Bahawalnagar                | 2567    | 2096      |
| 3       | Depalpur                                           | 1684    | 1794      |
| 4       | Oil Seed Research Sub Station, Piplan              | 1717    | 1960      |
| 5       | Adaptive Research Farm, Vehari                     | 2320    | 2038      |
|         | Average yield                                      | 2488    | 2220      |
|         | % increase over check                             | 12.07   |           |
| 1       | Wheat Research Institute, Faisalabad               | 2242    | 1981      |
| 2       | Horticultural Garden, Renalakshard Okara           | 1701    | 1714      |
| 3       | Oil Seed Research Sub Station, Piplan              | 2234    | 2124      |
|         | Average yield                                      | 2059    | 1940      |
|         | % increase over check                             | -       | 6.13      |
| 1       | Wheat Research Institute, Faisalabad               | 2649    | 2494      |
| 2       | Horticultural Garden, Renalakshard Okara           | 2838    | 3327      |
| 3       | Rice Research Institute, Kala Shah Kaku           | 2539    | 2274      |
| 4       | Gram Research Sub Station, Kallur Kot              | 2862    | 2601      |
| 5       | Adaptive Research Farm, Karor                      | 2732    | 2584      |
|         | Average yield                                      | 2724    | 2656      |
|         | % increase over check                             | -       | 2.6       |
| 1       | Wheat Research Institute, Faisalabad               | 3597    | 2394      |
| 2       | Govt. Seed Farm Dhakkar, Pakpattan                 | 4168    | 2877      |
| 3       | MMRI, Yousafwala Sahiwal                           | 3022    | 2699      |
| 4       | Adaptive Research Farm, Gujanwala                 | 2736    | 2708      |
| 5       | Rice Research Institute, Kala Shah Kaku           | 3097    | 2528      |
|         | Average yield                                      | 3324    | 2695      |
|         | % Increase over check                             | -       | 23.34     |
|         | Average yield (five years)                         | 2649    | 2378      |
|         | % increase over check (five years)                 | -       | 11.40     |
commercial check variety Haider-93. Its grain size was bold with thousand grain weight ranging from 34.43 to 41.53 and protein contents from 12.0 to 13.7% while test weight range was from 52.7 to 58.0 kg/hl (Table 6). Similar results were confirmed by Abdullah et al. (2021).

This proposed variety was further tested with 2-rowed head type commercially malt producing cultivars named MB-RWP-A and MB-RWP-B which were presently in use by famous private companies of Pakistan for the purpose of malt production at commercial scale (Table 7). The quality standards of starch contents & pearled grain weight of B-09008 resemble with the commercial cultivars to a great extent.

**Botanical attributes of Jau-17**

Jau-17 had medium to tall stature of about 99 to 110 cm length, growth habit was semi erect and had medium-length-awned ear which had whitish white color. It took 90 to 100 days to complete heading and matured in 140 to 145 days with good tillering capacity (154-160 per m). Its amber colored seed was medium to bold sized and elliptical with deep groove and had opaque surface. For quality trait evaluation, it had good quantity of protein (12.2 to 13.7%) and test weight (52.7 to 54.4 kg/hl) along with opaque seed surface. Its malt making quality was excellent for industrial uses. Finding were inline with those of Abdullah et al. (2021) and Petcu et al. (2019).

**Distinctiveness, uniformity and stability (DUS) test & final approval from expert Sub Committee (ESC) and Punjab Seed Council (PSC)**

After successfully out yielding the commercial check variety Haider-93 in Station and Out-station yield trials,

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**Table 4. Yield performance of “B-09006” in rainfed yield trials**

| Year       | 2015-16 | 2016-17 |
|------------|---------|---------|
| Normal irrigation | 2509    | 3459    |
| Rainfed conditions | 2381    | 2811    |
| Average yield | 2445    | 3135    |

% increase over check (Two years) 14.86

**Table 5. Disease reaction of B-09008 in local diseases screening nursery during 2014-15 to 2015-16**

| Location   | Rust | 2014-15 | 2015-16 |
|------------|------|---------|---------|
| Bahawalpur | LR   | 0       | MRMS    |
|            | YR   | 0       | 0       |
| Khanewal   | LR   | 0       | TMS     |
|            | YR   | 0       | 0       |
| Faisalabad | LR   | 0       | 0       |
|            | YR   | 0       | 0       |
| Islamabad  | LR   | TMR     | 5MS     |
|            | YR   | 0       | TMS     |
| Pirsabak   | LR   | 0       | TMS     |
|            | YR   | 0       | 0       |
| Peshawar   | LR   | TMR     | 10MS    |
|            | YR   | 0       | 10MS    |

LR = Leaf rust, YR = Yellow rust, TMR = Traces moderately resistant, TMS = Traces moderately susceptible, MS = Moderately susceptible, MRMS = Moderately resistant moderately susceptible

**Table 6. Quality characteristics of B-09006 from 2012-13 to 2015-16**

| Quality Characteristics | 2013-14 | 2014-15 | 2015-16 |
|-------------------------|---------|---------|---------|
| 1000 Grain wt. (g)      | 41.53   | 34.43   | 36.3    |
| Test wt. (kg/hl)        | 58      | 52.7    | 54.4    |
| Protein (%)             | 12      | 13.7    | 12.2    |

**Table 7. Quality characteristics of B-09008 compared with commercial cultivars**

| Entry Name   | Moisture % | Protein % | Starch % | Hardness Hl | Diameter mm | 1000 kernel weight (gm) | Pearled grain weight g out of 100 g husked |
|--------------|------------|-----------|----------|-------------|-------------|-------------------------|------------------------------------------|
| MB- RWP-A    | 10.6       | 10.3      | 59.3     | 57          | 2.71        | 40.98                   | 71.15                                    |
| MB-RWP-B     | 11.2       | 9.3       | 59.6     | 63          | 2.66        | 38.06                   | 68.40                                    |
| Jau-17       | 10         | 11.9      | 58.8     | 64          | 2.67        | 47.86                   | 73.60                                    |
| Haider-93    | 11.6       | 10.87     | 58.4     | 60          | 2.57        | 33.71                   | 65.70                                    |

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it was tested in DUS trials consecutively for two years starting from 2015-16 to 2016-17 where it performed well and showed the specific, stable and uniform characteristics. After DUS test, the variety Jau-17 got a successful spot examination by the scientists and researchers of the Punjab Agriculture Department and on the basis of that it was presented to 78th meeting of Experts Sub Committee of Elite Researchers and stakeholders, who recommended it for Punjab Seed Council for final approval as a separate variety. Later on it finally got approval from Punjab Seed Council for general cultivation throughout the Punjab province firstly for two years during 2017 and finally for continuous cultivation in 2019.

CONCLUSION
It was concluded from the current research that newly developed barley variety Jau-17 showed high yield, resistance to rust disease, superior quality traits as well as gave loftier performance under rainfed conditions as compared to other varieties. So, its cultivation in water stress area as well as different agro-ecological zones is recommended for better yield at farmers’ field.

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## CONTRIBUTION OF AUTHORS

| Sr. No. | Author’s name            | Contribution                                                   | Signature |
|---------|--------------------------|----------------------------------------------------------------|-----------|
| 1.      | Muhammad Riaz            | Managed the trial and reviewed the paper                       |           |
| 2.      | Muhammad Ijaz Tabassum   | Prepared the manuscript                                        |           |
| 3.      | Abdullah                 | Conducted the research                                         |           |
| 4.      | Muhammad Sarwar          | Proof read the manuscript                                      |           |
| 5.      | Muhammad Hammad Tanveer  | Assisted in data tabulation                                    |           |
| 6.      | Muhammad Abdullah        | Helped in research trial                                       |           |
| 7.      | Iqra Ghafoor             | Collected the data                                              |           |
| 8.      | Mehwish Makhdoom         | Helped in write-up the manuscript                              |           |
| 9.      | Javed Ahmad              | Supervisor                                                     |           |