



Research Article

Development of Bagh-o-Bahar Raya: A Newly Bred High-Yielding Mustard Cultivar Released for General Cultivation in Punjab, Pakistan

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Abstract | The edible oil import bill is posing a huge burden on the foreign reserves of Pakistan. Enhancing local production through breeding high-yielding cultivars is the possible solution. The present research work was carried out at Oilseeds Research Station Khanpur from 2006-21. The main objective was to develop a mustard cultivar with improved quantitative and qualitative traits. Bagh-o-bahar Raya is the name for strain KJ-238 and is an outcome of pedigree selection after hybridizing KJ-206 and J90-43001 genotypes. Its maximum grain yield (3306 kg ha⁻¹) was recorded at the Sahiwal location in national trials during 2017-18. Mean oil recovery was 38% with an average grain yield of 2048 kg ha⁻¹ across twelve test locations in the national trial. It showed a 17% higher grain yield than the check variety (Khanpur Raya) at the station yield trials. This newly bred cultivar takes 133-142 days from sowing to maturity. Thousand seed weight ranges from 5.10 to 5.23 grams. Its average stature is 157-171 cm and possesses tolerance against aphids and diseases especially Alternaria blight and White rust. It yielded the highest (2891 kg ha⁻¹) at the NPK@ 80:40:40 level. The optimum yield was produced (1976 kg ha⁻¹) when sown on 30th September. Its cultivation on a commercial scale will enhance the share of local edible oil production and will strengthen the national economy.

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Introduction

Edible oil production in the country is only 14.3% of its domestic requirement. Pakistan has spent (US\$ 3.81 billion) during 2021-22 on edible oil imports (GOP, 2021-22). Pakistan's edible oil

import bill is ranked the second biggest after fossil fuel (Ahmad *et al.*, 2013). The edible oil demand is increasing yearly due to the population increase. The major share of imported oil is palm oil, which is rich in saturated fatty acids and inferior in quality causing many health problems (Aftab *et al.*, 2021). Rapeseed

and mustard are the country's second-largest source of edible oil production after cotton seed. Pakistan is recently producing 375 thousand tons of rapeseed and mustard from an area of 277 thousand hectares (GOP, 2021-22).

Enhancing local edible oil production is the only solution to reduce the import bill and save foreign exchange. Brassica crops are one of the world's most important edible oil production sources (Nath *et al.*, 2016). Rapeseed and mustard are rich sources of oil (35-45%) and protein (30-35%). Breeders must choose the best parental combinations for cultivar development which are stable across erratic environments (Abbadi and Leckband, 2011). The mustard (*Brassica juncea*) crop has a long history of cultivation in this region and possesses good adaptability. It is very popular among farmers due to its unique features like better yield, shattering resistance, uniform ripening, lodging resistance and heat stress tolerance.

Old mustard varieties are low yielding, and susceptible to lodging in the field. Due to the late maturing habit, these types of varieties are damaged by aphids at the fruiting stage. Early maturing and short-duration cultivars will escape from aphid infestation. Mustard oil is used for edible and non-edible purposes in the world (Tahira *et al.*, 2013). It was hypothesized that breeding for high-yielding, early maturing and resistant to insect pests cultivars will boost edible oil production in the country and will help in reducing the import bill. Such cultivars will also facilitate the sowing of spring mung bean and early cotton crops.

Considering the above objectives, the technical team at Oilseeds Research Station Khanpur planned to develop brassica cultivars with superior quantitative and qualitative traits. As an outcome of such continuous efforts, this high-yielding and short-duration cultivar were developed by conventional breeding methods. Its approval by the provincial seed council will help reduce the gap between producing and consuming good quality edible oil.

Materials and Methods

The present breeding work was carried out at the Oilseeds Research Station Khanpur (located in south Punjab, Pakistan) from 2006-21. The climate of the breeding station was arid with 40-52 mm average rainfall and the soil was the loamy type. A

well-adapted mustard genotype (J90-43001) was selected as a female parent and a bold-seeded and early-maturing mustard strain (KJ-206) was selected as a male parent. Both of the genotypes were grown in the crossing block during 2006-07 and a cross was attempted between them. The Hybrid seed obtained was sown to raise the F_1 generation in the coming winter season. Progeny rows were raised to F_7 to achieve maximum homozygosity by adopting the pedigree method of selection (Table 1). Four uniform and vigorous progeny rows were selected from the F_7 generation and evaluated in yield trials at the breeding station during 2014-15 and 2015-16. The randomized complete block design (RCBD) was followed in yield trials with three replications and the plot size was kept at 5m x 1.8 m. Sowing was completed with the help of a drill by maintaining a distance of 0.45m between the rows. Manual thinning maintained a distance of 0.1m at the four-leaf stage between the plants. All recommended agronomic and cultural practices were applied uniformly to all treatments. Data were recorded for days to flowering, days to maturity, plant height, seed yield, and yield-related traits. An edible oil quality test was performed with near-infrared reflectance spectroscopy (Model; Perten DA 7250) at the oilseeds research institute in Faisalabad Pakistan. Based on overall performance, one genotype was selected (KJ-238) and evaluated at multi-location trials during 2016-17. After that this potential strain KJ-238 was evaluated under the national trial for two consecutive years. Agronomic trials like the best sowing date and optimum fertilizer required to achieve the potential yield were conducted at the breeding station. Pathological studies were also carried out, and this genotype's disease response against major diseases was recorded.

Statistical analysis

Grain yield data in kg ha^{-1} was subjected to the ANOVA technique (Steel *et al.*, 1997) and means were compared by using the least significance difference (LSD) test (Fisher, 1935) at a 5% level of confidence. Statistix 8.1 version software was used for the data analysis.

Results and Discussion

Bagh-o-Bahar Raya was named for the strain KJ-238 derived from the cross KJ-206×J90-43001. Mustard genotype (J90-43001) was selected as a parent because it was well adapted to the environmental conditions

Table 1: Various steps in the breeding of mustard cultivar Bagh-o-Bahar Raya.

Year	Generation/ Trials	Remarks
2006-07	Initial cross	Cross was attempted (KJ-206 × J90-43001) and F ₀ seed was harvested.
2007-08	F ₁ was raised	F ₁ seed was harvested for F ₂ planting.
2008-09	F ₂ was raised	95 single plants were selected and harvested separately for F ₃ planting.
2009-10	F ₃ was raised	34 desirable single plants were harvested from selected rows for F ₄ planting.
2010-11	F ₄ was raised	25 desirable single plants were harvested from selected rows for F ₅ planting.
2011-12	F ₅ was raised	12 desirable single plants were harvested from selected rows for F ₆ planting.
2012-13	F ₆ was raised	09 desirable single plants were harvested from selected rows for F ₇ planting.
2013-14	F ₇ was raised	04 superior rows were selected on a visual look and oil quality basis for testing in yield trials.
2014-15 and 2015-16	Yield trials	04 selected rows were tested in replicated trials at the station (Khanpur).
2016-17	Zonal varietal yield trial	One promising strain KJ-238 was evaluated at eight locations as mentioned in Table 3.
2017-18 and 2018-19	National uniform mustard yield trial	This trial was conducted under the control of oilseed coordinator NARC Islamabad throughout the country at locations as mentioned (Tables 4 and 5).
2018-19 and 2019-20	Distinctiveness, uniformity and stability (DUS) studies	Data on DUS parameters were recorded by the federal seed certification and registration department at Pirowal.
2020	Spot examination	The performance of the candidate strain was observed at Khanpur and Faisalabad locations, evaluated by the committee, and recommended for approval.
2016	Approval	Based on superior performance in the field Bagh-o-Bahar Raya was approved by the seed council for general cultivation in Punjab.

and bears disease tolerance while the other parental genotype (KJ-206) was possessing high-yielding, bold seeded and early maturing traits. In crop breeding, genetic variability among parental genotypes has a dynamic role in developing stable cultivars (Belete, 2011). In conventional breeding, hybridization is used to create genetic variation and then followed by a selection of superior sergeants based on plant stature, maturity period, pod shape, seed size and colour. The pedigree method of selection was followed in this study. A similar procedure was adopted by Mahmood *et al.* (2012) in the breeding of the rapeseed cultivar Faisal canola.

Table 2: Yield performance (kg ha⁻¹) of KJ-238 in station yield trials.

Strain/ Variety	Seed yield in kg ha ⁻¹		Average.	% increase over check
	PYT (2014-15)	AYT (2015-16)		
KJ-238	2993	3025	3009	15
Khanpur Raya (Check)	2515	2613	2564	
LSD 5 %	106	210		
C.V%	10.5	13.9		

When sufficient homozygosity was achieved in the F₇ generation, yield trials were initiated at the

breeding station for two years. In such trials, KJ-238 yielded 15 per cent higher than the check variety (Table 2). This strain continued its superior performance in a multi-location trial conducted at eight sites in the province and produced 13 per cent more grain yield (Table 3) as compared to the check. These results were encouraging and in line with the findings observed by Mustafa *et al.* (2022) during the breeding of the cultivar sandal canola. The yield data in national trials is very important concerning the variety approval. In this regard, this strain (KJ-238) produced a 6 per cent increased yield (Table 4) under the national uniform mustard yield trial (NUMYT) conducted at twelve locations throughout the country during 2017-18. The cultivar Super Raya was used to compare the yield performance in this trial. The yield increase was recorded at 4 per cent in the NUMYT trial (Table 5) during 2018-19 and was conducted at eleven sites. The relative decline in yield performance in NUMYT concerning the check cultivar was due to the better yield of Super Raya as a check variety. These results confirmed the findings obtained by Nadeem *et al.* (2017) during the breeding of the cultivar Rohi Sarsoon.

The performance of a genotype in the field depends upon appropriate production technology. For this purpose, agronomic trials for the strain (KJ-238)

Table 3: Yield performance (kg ha^{-1}) of KJ-238 in a multi-location trial during 2016-17.

Strain/Variety	Seed yield in kg ha^{-1}								Av.	% increase over check
	Faisalabad	Bahawal nagar	Bahawalpur	Gujranwala	Khanpur	Chakwal	Karor	Piplan		
KJ-238	2233	1914	2778	1572	3485	551	1599	1972	2200	13
Khanpur Raya (Check)	2052	2840	2565	2325	1682	449	1038	2315	1946	
LSD 5%	110	225	135	228	165	45	220	115		
C.V%	12.0	9.8	13.2	14.1	9.6	12.4	17.2	10.5		

Table 4: Yield performance (kg ha^{-1}) of KJ-238 in a national uniform mustard yield trial during 2017-18.

Strain/Variety	Seed yield in kg ha^{-1}												Average	% increase over check
	NARC Islama-bad	BARI Chak-wal	ORI Faisal-abad	RARI Baha-walpur	Pioneer Sahiwal	ORS Khan-pur	BARS Fateh Jang	AZRI D. I. Khan	AZRI Bhakkar	NIFA Pesha-war	ARI Tando Jam	ARI Quet-ta		
KJ-238	2848	628	3120	2472	3306	1741	476	2907	2016	3071	1654	740	2048	6
Super Raya (Check)	2562	507	2817	2278	2461	1989	623	2686	1859	3375	1389	488	1928	
LSD 5%	110	80	150	130	215	115	85	155	102	210	220	155		

Table 5: Yield performance (kg ha^{-1}) of KJ-238 in a national uniform mustard yield trial during 2018-19.

Strain/Variety	Seed yield in kg ha^{-1}											Average	% increase over check
	NARC Islama-bad	BARI Chak-wal	ORI Faisal-abad	RARI Baha-walpur	ORS Khan-pur	BARS Fateh Jang	AZRI D. I. Khan	AZRI Bhakkar	NIFA Pesha-war	NIA Tando-Jam	ARI Tando-Jam		
KJ-238	2167	1092	2759	2633	2000	990	2531	728	2997	996	1794	1881	4
Super Raya (Check)	1868	1218	2778	2500	2130	1052	2428	803	2731	796	1556	1805	
LSD 5%	102	91	220	85	110	157	230	135	185	82	210		

were conducted at the breeding station. The best sowing date for optimum grain yield (Table 6) was found on 30th September in trials conducted at the breeding station during 2017 and 2018. The grain yield declined gradually as the sowing was performed at later dates. Shabbir *et al.* (2011) also found 1st October as the best sowing date for the variety Chakwal Sarsoon. This decline in yield in the late-sown crop was due to the reduced vegetative growth period because of the winter season. The nutrient application in the form of chemical fertilizers is important to harvest the best yield as our soils have become deficient in essential ingredients required for healthy plant growth. The highest grain yield (2891 kg ha^{-1}) was achieved when NPK@80:40:40 was applied (Table 7). These encouraging results are due to the application of balanced nutrients. These results are in line with the findings observed by Singh *et al.* (2019) during the breeding of the mustard variety CS-58.

Table 6: Yield performance of KJ-238 to different planting dates at the breeding station.

Sowing date	Yield in kg ha^{-1}		Average yield kg ha^{-1}
	2017-18	2018-19	
30 th September	1931 ^a	2022 ^a	1976
10 th October	1755 ^b	1832 ^b	1793
20 th October	1449 ^c	1771 ^b	1610
30 th October	1297 ^d	1395 ^c	1346
LSD 5%	85	115	
C.V%	11.6	18.9	

Figures bearing a similar alphabet are non-significant at ($p \leq 0.05$).

The disease response of the strain KJ-238 was recorded with the check cultivar at the breeding station for two years (Table 8) and found that a sufficient amount of tolerance was present in the new strain for major diseases. Mahmood *et al.* (2012) and Mustafa *et al.* (2022) followed the same procedure for disease response assessment in their experiments. The

seeds of promising strain KJ-238 bears 38 per cent edible oil contents. The distinctiveness uniformity and stability (DUS) studies have been completed for this strain during the years 2018-19 and 2019-20. The spot examination committee evaluated the performance of KJ-238 in the field along with the check cultivar and recommended it for consideration in the expert sub-committee. Later on, the Punjab seed council approved the KJ-238 strain with the name Bagh-o-Bahar Raya for general cultivation in the whole province of Punjab, Pakistan.

Table 7: Yield performance of KJ-238 to different fertilizer levels at Khanpur during 2019-20.

N dose (kg ha ⁻¹)	P dose (kg ha ⁻¹)	K dose (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)
60	0	0	2141 ^d
80	0	0	2375 ^c
90	0	0	2200 ^d
60	40	30	2690 ^b
80	40	40	2891 ^a
90	40	40	2410 ^c
60	60	60	2620 ^b
80	60	60	2455 ^c
90	60	80	2340 ^{cd}
LSD 5%			150
C.V%			14.5

Figures bearing a similar alphabet are non-significant at ($p \leq 0.05$).

Table 8: The disease response of KJ-238 at the breeding station.

Variety/ Strain	Year	Alternaria Blight	Powdery mildew	White rust
2017-18	KJ-238	0	2	0
	Super raya (C)	1	4	0
2018-19	KJ-238	0	0	1
	Super raya (C)	0	2	3

0: Resistant; 9: Susceptible.

Conclusions and Recommendations

It is concluded from this study that the newly bred variety Bagh-o-Bahar Raya is superior in grain yield to the existing mustard varieties. Its best sowing date is 30th September and the optimum nutrient level for the maximum yield is NPK@80:40:40 in the form of chemical fertilizer. It also showed better tolerance against major diseases. Its cultivation on a commercial scale will enhance edible oil production at the national level and decrease the import bill.

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Novelty Statement

The newly bred variety Bagh-o-Bahar Raya is a high-yielding mustard variety bred by the pedigree method after planned hybridization. Its release and cultivation on large scale will boost edible oil production at the national level.

Author's Contribution

IA and SS: Completed the national yield trials, conducted the spot examination and pursued the case for the release of this variety.

MJ: Raised the filial generations and wrote the manuscript.

IA: Prepared the tables.

HMZU: Conducted the pathological trial.

SAM and UF: Reviewed the recent literature.

MA: Analyzed the data.

AMK: Conducted the station yield trials. NI proofread the manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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