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"Barani Sarsoon" A Novel Combination of Enviable Genetic Characters of Rapeseed for Rainfed Areas

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ABSTRACT

The development of new crop varieties is a continuous process as old cultivars become susceptible to various biotic and abiotic stresses, thus decreasing the yield potential. The newly developed rapeseed variety "Barani Sarsoon" a high-yielding, disease resistant and drought tolerant has been developed through the selection method of breeding from the exotic material. A promising progeny of a single plant was selected and named "14CBN009". The performance of "14CBN009" was further evaluated along with standard varieties in various replicated yield trials for six years from 2014-15 to 2018-19. The selected line "14CBN009" produced a higher grain yield (kg/ha) than the standard varieties in all replicated yield trials with a yield potential of 3378 kg/hectare which is tolerant to drought and resistant to diseases. The best sowing time for this variety is from 25th September to 15th October with a seed rate of 2.50 kg/acre. The seed contains 44.53% oil content. The main yield contributing characters of "14CBN009" are pods per plant, seeds per pod and thousand-seed weight. Based on the desirable phenotypic and genotypic characteristics, higher grain yield and oil content percentage, "14CBN009" was approved as a rapeseed variety with the name of "Barani Sarsoon" by the Punjab Seed Council in its 55th meeting held on Sep 20, 2021, for commercial cultivation in the Punjab rainfed areas. Due to high yielding, drought and disease-tolerant characteristics, the new variety "Barani Sarsoon" will prove to be a good alternative to existing varieties and improve the production and income of the oilseed crops growers of the rainfed area.

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INTRODUCTION

Rapeseed (*Brassica napus* L.) is a major oilseed crop mostly grown for the extraction of oil in the world. Rapeseed oil is regarded as the third leading supplier of vegetable oil across the globe and meal is the second major source of plant protein in the feed of animals (USDA Economic Research Service, 2020). The total area under rapeseed in the world is about 34.7 million hectares, out of which 13.5 million hectares belong to Asia (FAO, 2019). The local production of oilseed crops including rapeseed/mustard and canola during 2020-21 was 387 thousand tons and total edible oil available in Pakistan was 3.29 million tons, whereas only 0.374 million tones *i.e.,* 13% of total available oil was produced locally and remaining 87% was imported by spending 574.19 billion rupees (GOP, 2021). Therefore, it is a dire need in the present situation to enhance the domestic production of oilseed crops to fulfil the demand of the ever-increasing population.

The abiotic stresses always adversely affected the production of rapeseed, mainly in arid and semi-arid areas. Climate change has been considered one of the

major restrictive aspects in the production of rapeseed in several parts of the world (Lobell and Gourdji, 2012). Drought stress is the major concern in most arid regions for the production of rapeseed (Wu and Ma, 2018). Hence, one of the most important objectives of crop breeding is to enhance genetic variation and the development of tolerant varieties of canola-type rapeseed to encounter new climatic conditions (Fischer and Edmeades, 2010). Rapeseed cultivation in Pakistan is affected by drought stress, especially in rainfed regions. Therefore, the development of new genotypes from the available rapeseed germplasm would be important to improve the genetic variations in rainfed areas. Alizadeh *et al*. (2021) evaluated thirteen rapeseed genotypes in different environments and found that four genotypes had higher grain yield and stability than the standard varieties. Rapeseed genotypes exhibited different yield potential across diverse environments because of their interaction with the environment. As the yield is a complex nature character which is controlled by numerous genes and highly affected by changing climatic conditions. So, the experimental sites having different ecological conditions should be kept in mind to recognize genotypes having the maximum stable yield under different prevailing environments (Agahi *et al*., 2020).

The average low grain yield of rapeseed is primarily due to lack of high-yielding and drought and disease-tolerant varieties and the non-availability of good quality seed. To overcome these main problems of the arid areas, the new variety "Barani Sarsoon" has been released for commercial cultivation having the best genetic characteristics like high yielding, high oil content, drought and disease tolerance. The current research paper describes the breeding history of the newly developed rapeseed variety "Barani Sarsoon" which was approved by the Punjab Seed Council in its 55th meeting held on Sep 20, 2021, for commercial cultivation in rainfed areas.

MATERIALS AND METHODS

The recently evolved rapeseed variety "Barani Sarsoon" a high-yielding, disease resistant and drought tolerant has been developed through the selection method of breeding from exotic material. A promising progeny of a single plant was selected and named "14CBN009". The performance of "14CBN009" was further evaluated along with check varieties in different replicated yield trials and screened for disease tolerance during 2014-15 to 2018-19 under rainfed conditions. The breeding history of the new variety "Barani Sarsoon" is given in Table-1. All replicated yield trials were conducted using a randomized complete block design with three replications while plant-to-plant and row-to-row spacing was kept at 10 cm and 45 cm respectively after thinning at the appropriate stage. For genetic divergence of the candidate variety, DNA was extracted from leaves and by using different SSR markers, the DNA fingerprinting of the candidate variety "Barani Canola" was done for the uniqueness of the variety from the existing varieties. The quality characters analysis was done at Oil Technology Lab at Oilseed Research Institute, Ayub Agricultural Research Institute, Faisalabad through Near Infrared Spectroscopy (NIRS). The data were analyzed statistically by using the statistix 8.1 software.

Table 1. Breeding History of Barani Sarsoon (14CBN009).

Year	Trials	Remarks
2014-15	Preliminary Yield Trial (PYT)	This trial was carried out at Barani Agricultural Research Institute, Chakwal
2015-16	Regular Yield Trial (RYT)	This trial was carried out at Barani Agricultural Research Institute, Chakwal
2013-15	Plant Protection Trials	These trials were conducted by the plant protection section at Barani Agricultural Research Institute, Chakwal
2016-17	Micro Yield Trial (MYT)	These trials were evaluated at diverse locations in Punjab under coded numbers carried out by the Director, of Oilseed Research Institute Faisalabad.
2015-17	Agronomic Trials	These trials were conducted by the agronomy section at Barani Agricultural Research Institute, Chakwal
2017-19	National Uniform Rapeseed Yield Trial	These trials were carried out by the National Coordinator oilseed crops, NARC Islamabad throughout Pakistan.

2019-21	DUS studies	Data of particular advanced lines was collected by Federal Seed Certification and Registration Department.
2021	Spot examination	The candidate breeding line was evaluated by the spot Examination Committee and was recommended for varietal approval
2021	ESC Recommendation	The candidate line was evaluated by the Experts Sub-Committee and was recommended for approval by Punjab Seed Council in its 81st meeting held on July 12, 2021.
2021	PSC Recommendation	14CBN009 was approved as a rapeseed variety with the name of "Barani Sarsoon" by the Punjab Seed Council in its 55th meeting held on Sep 20, 2021, for commercial cultivation in the Punjab rainfed areas.

RESULTS AND DISCUSSION

Yield Performance Trials

Rapeseed preliminary yield trial and rapeseed regular yield trial were conducted during the cropping season 2014-15 and 2015-16 respectively at Barani Agricultural Research Institute, Chakwal Pakistan. The results predicted that significant differences ($P<0.05$) were found among the varietal means for seed yield in the rapeseed preliminary yield trial (Table 2). The advanced line "14CBN009" gave a higher grain yield (1930 kg ha^{-1}) which was 2.76 % higher than Chakwal Sarsoon check variety and 4.95 % higher than the Faisal Canola check variety. Similarly, in a regular yield trial, the proposed line "14CBN009" on an average (2070 kg ha^{-1}) gave 2.63 % higher yield than check variety Chakwal Sarsoon and 14.62 % higher yield than check variety Faisal Canola (Table-3). The current research work is consistent with the study of Ozturk, (2019) and Sajid *et al*. (2021) who exposed that the grain yield of rapeseed genotypes was differed significantly probably due to the higher potential of parents.

Table 2. Grain yield of rapeseed genotypes in preliminary yield trial (2014-2015).

Sr. No	Entries	Grain Yield (kg/ha)	% increase over Chakwal Sarsoon (C)	% increase over Faisal Canola (C)
1	14CBN009	1930	2.76	4.95
2	Chakwal Sarsoon (c)	1878		
3	Faisal canola (c)	1839		
4	14CBN004	1828		
5	14CBN006	1789		
6	14CBN007	1786		
7	14CBN005	1734		
8	14CBN003	1608		
	LSD (0.05)	48		
	CV (%)	8.20		

Table 3. Grain yield of rapeseed genotypes in regular yield trial (2015-2016).

Sr. No.	Entries	Grain Yield (kg/ha)	% increase over Chakwal Sarsoon (C)	% increase over Faisal Canola (C)
1	14CBN009	2070	2.63	14.62
2	Chk. Sarsoon (c)	2017		
3	14CBN006	1990		
4	14CBN005	1982		
5	14CBN003	1936		
6	14CBN007	1930		
7	14CBN002	1869		
8	14CBN008	1868		
9	14CBN004	1842		
10	F. Canola (c)	1806		
	LSD (0.05)	41		
	CV (%)	6.90		

Regional adoptability trials

The candidate line "14CBN009" was tested in a micro yield trial during 2016-17 at four different locations (Bahawal Nagar, Khan Pur, Chakwal and Karore). The results demonstrated that the advanced line "14CBN009" gave 3.20 % higher grain yield than check variety Rohi Sarsoon and 3.00% than Faisal Canola (Table 4). The yield performance of "14CBN009" was then evaluated in the National Uniform Yield Trials during 2017-18 and 2018-19 at five different rainfed locations and results presented that the advanced line "14CBN009" performed better and showed 27% and 13.80% higher grain yield than international standard check Hyola-401 respectively (Table 5 and Table 6). The yield performance of "14CBN009" was found good in different yield trials. It is depicted from Table-7 that on an average of 16 yield trials "14CBN009" gave 2.50% and 20.88% higher seed yields than the check variety Faisal Canola and Hyola-401respectively. Sincik *et al*. (2021) investigated the stable yield performance overall environment and higher general adaptability of *Brassica napus* genotypes during their research work. Similar results were obtained by Miah *et al*. (2015), Rahnejat and Farshadfar (2015), and Nowosad *et al*. (2016), who also investigated the ideal *Brassica napus* genotypes having high yield and performing well under diverse environments.

Table 4. Grain yield of rapeseed genotypes in micro yield trials at four different locations (2016-17).

S. NO.	Line/ Variety	Bahawal Nagar	Khan Pur	Chakwal	Karore	Mean yield (kg/ha)	% increase over Rohi Sarsoon (C)	% increase over Faisal Canola (C)
1	Rohi Sarson (C)	1667	1713	456	1754	1398		
2	Faisal Canola (C)	1667	1512	519	1905	1401	3.22	3.00
3	14CBN009	1821	1821	506	1625	1443		

CV: 12.40, Genotype (G), Locations (L) and G*L different highly significant at (p<0.01).

Table 5. Grain yield of "14CBN009" at five locations in NURYT-2017-18.

Sr. No	Entry Name	BARI Chakwal	RARI Bahawalpur	ORS Khan Pur	BARS Fateh Jang	AZRI Bhakkar	Mean grain yield (kg/ha)	% increase over Faisal Canola (C)
1	Hyola-401 (C)	544	2644	1074	624	1404	1258	27%
2	14CBN009	609	3378	1204	762	2037	1598	

CV: 15.10, Genotype (G), Locations (L) and G*L different highly significant at (p<0.01).

Table 6. Grain yield of "11CBN006" at four locations in NURYT-2018-19.

Sr. No	Entry Name	BARI Chakwal	RARI Bahawalpur	ORS Khan Pur	BARS Fateh Jang	AZRI Bhakkar	Mean grain yield (kg/ha)	% increase over Faisal Canola (C)
1	Hyola-401 (C)	1192	1250	1370	625	927	1073	13.80%
2	14CBN009	2035	1055	1315	615	1087	1221	

CV: 14.60, Genotype (G), Locations (L) and G*L different highly significant at (p<0.01).

Table 7. Overall yield performance of "14CBN009" in different yield trials.

Year	Trial	Locations	Grain Yield (kg/ha)		
			14CBN009	Faisal Canola (check)	Hyola-401 (check)
2014-2015	PYT	1	1930	1839	-
2015-2016	RYT	1	2070	1806	-
2016-2017	MYT	4	1443	1401	-
2017-2018	NURYT	5	1598	1402	1258
2018-2019	NURYT	5	1221	-	1073
Mean		16	1652	1612	1166
Yield increase (%) over Checks				2.50	20.80

Agronomic Trials

The experiments were designed to find out the best sowing time for a new variety to achieve higher grain yield under rainfed conditions during 2015-16 and 2016-17. It was concluded that significant differences were found among the various sowing dates for grain yield. It is exposed that "14CBN009" gave a higher grain yield when sown on 1st October followed by 15th October and the lowest grain yield attained when the crop was drilled on 1st December during both years respectively (Table 8). Genotype "14CBN009" was sown at different fertility levels to find out the optimum fertilizer requirements. The experiment was conducted during 2015-16 and 2016-17 on sandy loam soil which was deficient in organic matter (0.56 & 0.49%), available phosphorus (6.7 & 6.4 mg/kg) and pH of 8.0 & 8.1 respectively. On an average two-year study, "14CBN009" gave a better response to fertilizer dose @ 75-50-0 kg/ha NPK (Table 9).

The important point is that the date of sowing plays a vital role in rapeseed production. Decreased yield due to late sowing is directly associated with a delay in flowering time and a reduced flowering period which ultimately result in a reduction in the grain yield of rapeseed (Shafighi *et al*., 2021). So, based on experimental data, the best sowing date for the newly developed variety Barani Sarsoon (14CBN009) was recommended from 25th September to 15th October for rainfed areas of Punjab, Pakistan.

Table 8. Average grain yield of "14CBN009" as affected by various sowing dates during 2015-16 and 2016-17 .

Sowing Dates	Yield (kg/ha) 2015-16	Yield (kg/ha) 2016-17
1st September	1718	430
15th September	1870	570
1st October	2140	764
15th October	1960	623
1st November	1710	501
15th November	1448	452
1st December	1401	413
LSD (0.05)	94	58
CV (%)	6.10	8.70

Table 9. Grain yield of "14CBN009" as affected by various fertilizer levels during 2015-16 and 2016-17

S. No.	N kg/ha	P kg /ha	Yield (kg/ha) 2015-16	Yield (kg/ha) 2016-17
1	0	0	1671	383
2	0	50	1695	401
3	0	75	1699	424
4	50	0	1681	420
5	50	50	1942	510
6	50	75	2076	543
7	75	0	2092	561
8	75	50	2465	682
9	75	75	2380	652
10	100	0	2140	431
11	100	50	2101	449
12	100	75	1985	410
		Genotype	Fertilizer	Interaction
LSD (0.05)		47	19	38
CV (%)		8.20		

Plant Protection Trials

Two experiments were conducted for screening of "14CBN009" against disease resistance during 2015-16 & 2016-17 and disease scoring data are presented in Table-10. The advanced line "14CBN009" showed resistance against powdery mildew and Alternaria blight diseases. It is important to mention here that "14CBN009" escaped from an aphid attack when it was sown at the proper time. Our results are in accordance with the conclusion of Alkooranee *et al*. (2015) and Uloth *et al*. (2018) who reported that rapeseed genotypes had resistance against different diseases.

Table 10. Screening of "14CBN009" against diseases resistant 2015-16 & 2016-17.

Sr No	Entry	Scale*			
		2015-16		2016-17	
		Powdery Mildew	Alternaria Blight	Powdery Mildew	Alternaria Blight
1	14CBN009	0	0	0	0
2	Ch. Sarsoon	1	0	1	0

*0: Resistant, 5: susceptible.

Quality Parameters

The findings of quality parameters analysis through Near Infrared Spectroscopy revealed that genotype "14CBN009" produced higher oil content (44.53%) than standard check Faisal canola (39.31%) (Table-11). After grain yield, Oil content is one of the most essential criteria for the development of new varieties in oilseed crops. The oil percentage and quality depend on the genetic makeup of the new variety and its expression in different climatic conditions (Balalic *et al*., 2017; Kahrarian *et al*., 2014).

Table 11. Comparison of quality analysis of Barani Sarsoon (14CBN009) and Faisal canola (Check).

Name of Line/Variety	Oil (%)
Barani Sarsoon (14CBN009)	44.53
Faisal Canola (Check)	39.31

Botanical Description

Barani Sarsoon is an erect type of variety with an average plant height of 168 cm. The colour of the plant is green with a determinate growth habit. The leaf colour is green with a wax coating. This variety takes an average of 75 days to 50% flowering. Its average 1000 seed weight and pod length have been observed about 4.30 g and 6.5cm respectively. Its seed colour is blackish brown (Table 12).

Table 12. The important characteristics of the new rapeseed variety "Barani Sarsoon" and check variety Faisal Canola on average basis.

Characteristics	Barani Sarsoon (14CBN009)	Faisal Canola (Check)
Seed Colour	Blackish Brown	Dark Brown
Days to 50% flowering	75	82
Days to maturity	173	182
Plant height(cm)	168	183
No of primary branches/plant	11	10
Silique length (cm)	6.50	6.0
Siliques /plant	701	609
Seeds / Silique	24	19
1000 grain weight (gm)	4.30	3.60

DNA fingerprinting of "Barani Sarsoon"

DNA fingerprinting is now a prerequisite for the approval of a new variety in Punjab, Pakistan. So, for this reason, DNA was extracted from leaves and by using different SSR markers, the DNA fingerprinting of the candidate variety "Barani Sarsoon" was done. Cultivar Identification Diagram (CID) based on the DNA fingerprinting report (Table 13), presented the association between standard varieties (Sandal Canola, Super Canola and Faisal Canola) and the candidate variety "Barani Sarsoon" (14CBN009), which was generated by unweighted paired group method with arithmetic means (UPGMA). X-axis represents the genetic similarity coefficient between genotypes which ranged from 0.48 to 0.96 (Figure-1). It is indicated in CID results that the candidate variety "Barani Sarsoon" varied significantly from the standard varieties i.e., Sandal Canola, Faisal Canola and Super Canola which showed 52% dissimilarity. Huma *et al*. (2020) also studied the genetic divergence in different genotypes of rapeseed by using SSR markers and found genetic similarity coefficient ranged from 0.28 to 0.85.

Table 13. Size of DNA fragment/amplicon (bp) used for DNA fingerprinting of "Barani Sarsoon".

Sr. No.	Name of Marker	Size of DNA Fragment / Amplicon (bp)			
		Standard-I (Sandal Canola)	Standard-II (Super Canola)	Standard-III (Faisal Canola)	Candidate Variety (14CBN009)
1	ABRJ-01	80,100,160	100	100,500	100
2	ABRJ-02	90,110,125,150	90,110,125,150	90,110,125	150,175,250,270
3	ABRJ-03	-	-	-	-
4	ABRJ-04	70,90,110,140,160,170,280,300	70,90,110,140,160,170,280,300	70,90,110,160	90,140
5	ABRJ-05	80,95	80,95	80,95	95
6	ABRJ-06	135,180,240	135,180,240	135,180,240	200,240
7	ABRJ-07	85,150	85,150	85	150
8	ABRJ-08	200	200,260	200	260
9	ABRJ-09	75	75,110,135	75,110,135	75,135,200
10	ABRJ-10	60	60	60	-
11	ABRJ-11	200	-	220	-
12	ABRJ-12	60,80,185,220,235	60,220,235	60,80,185,220,235	-
13	ABRJ-13	420,750	420,510	420,780	-
14	ABRJ-14	60,180,190	60,190	60,190	60,180,190,220
15	ABRJ-15	90,135	-	90,135	90,135
16	ABRJ-16	-	-	-	220,300,350
17	ABRJ-17	85,250	85,250	75	75,85
18	ABRJ-18	105,320	105,320	105,300,320	105,320
19	ABRJ-19	65	65,150,160	65	65,80,160
20	ABRJ-20	70,80	70,80	70,80	70,80
21	ABRJ-21	120,135	10,135,150	120,135	170
22	ABRJ-22	-	140	-	-
23	ABRJ-23	90,100	90,100	90,100	175,270
24	ABRJ-24	130	120,140,155	155	70
25	ABRJ-25	-	70,145,160	70,145,160	70
26	ABRJ-26	90,110,140	90,110,140	90,110,140	90,140
27	ABRJ-27	-	-	75	75
28	ABRJ-28	-	60,90	-	90
29	ABRJ-29	75,125,150	75,125,150	75,125,150	1,255,150
30	ABRJ-30	160,185,200	150,185,200	80,160,185,200	160,185
31	ABRJ-31	-	70,80	70,80	70
32	ABRJ-32	-	-	-	-
33	ABRJ-33	65,10	120	65,120	120,140
34	ABRJ-34	65,75	65,75	65,75,90	65,75
35	ABRJ-35	65,145	65	65	65,145
36	ABRJ-36	145,165,175	145,165,175,215,225	145,165,175	90
37	ABRJ-37	90,125	90,125	90,125	90
38	ABRJ-38	-	-	-	-
39	ABRJ-39	240,260	240,260	240,260	-
40	ABRJ-40	250,275	250	260	-
41	ABRJ-41	60,110,135,145	60,110,135,145	60,110,135,145	145
42	ABRJ-42	130,140,160	130,140,160	130,140,160	130,140,160
43	ABRJ-43	70,260,520,550	70,260,300,520,550	70,100,260,550	70,220
44	ABRJ-44	240,250	-	240,250	-
45	ABRJ-45	70,220	220	70,220	70
46	ABRJ-46	110,160,190	110,160,190	110,160,190	110,160,250
47	ABRJ-47	70,90,180,190	70,90,180,190	70,90,180,190	70,90
48	ABRJ-48	190,200,600	190,200,600	190,200,600	190,200,240
49	ABRJ-49	70	270,200	70,200	70,110,135,230
50	ABRJ-50	230	230,250	230	250

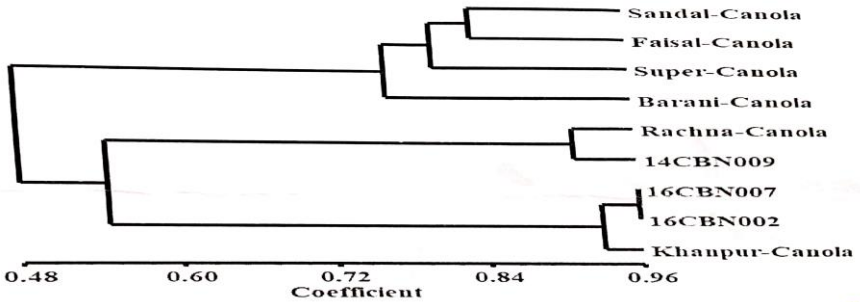

Figure 1. Cultivar Identification Diagram (CID).

Justification for the recommendation of the variety "Barani Sarsoon"

Barani Sarsoon (14CBN009) showed good yield potential in different yield trials than standard varieties. On an average of yield trials (2014-2019) 14CBN009 gave 2.50 and 20.80 % higher grain yield than standard varieties, Faisal Canola and Hyola-401 respectively. It is a drought-tolerant and disease-resistant variety and has higher oil contents than Faisal Canola. Barani Sarsoon (14CBN009) has an average of 701 pods per plant whereas Faisal Canola has an average of 609 pods per plant. The average thousand seed weight of Barani Sarsoon (4.30g) is more as compared to Faisal canola (3.60g) in rainfed conditions and the yield potential of Barani Sarsoon (14CBN009) is 3378 kg/ha.

CONCLUSION

The main yield contributing characters of "14CBN009" are pods per plant, seeds per pod and thousand-seed weight. Its cultivation on large scale will not only enhance productivity but also this cultivar catches more prices in the market as compared to traditional rapeseed varieties. Due to high yielding, drought-tolerant and disease-resistant characteristics, the new variety "Barani Sarsoon" will prove to be a good substitute for existing varieties and enhance the productivity and income of the oilseed crops growers of the rainfed area.

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AUTHORS CONTRIBUTION

TH Conceived idea, designed the research methodology, collected, analyzed and interpreted data and write up the manuscript; RM helped in literature research and preparation of the manuscript; SN helped in writing and editing the manuscript; JA helped in designing the research methodology and SA reviewed and approved the final draft.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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