

BARS-09: A HIGH YIELDING AND RUST RESISTANT WHEAT (*TRITICUM AESTIVUM* L.) VARIETY FOR RAINFED AREAS OF PUNJAB

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ABSTRACT

BARS-09 is a semi dwarf, rust resistant, drought tolerant and high yielding wheat variety developed as a result of consistent breeding efforts from the year 1999-2007 at Barani Agricultural Research Station (BARS), Fatehjang, Pakistan. The variety was developed from the cross "PFAU/SERI//BOW" and selected from the 16th Semi Arid Wheat Screening Nursery. The genotype was evaluated in multiple trials (preliminary, adaptation, station and regular) from 1999-2000 to 2002-03 under the varietal code 99FJ03. It was further tested in micro yield trial (rainfed) conducted at seven locations in Punjab during 2003-04. The line was also evaluated in National Uniform Yield Trial (rainfed) for two consecutive years 2005 to 2007. It stood third in National Uniform Yield Trials (2006-07) conducted both in Punjab and Pakistan. BARS-09 has shown yield potential of 5613 kg per hectare at Barani Agricultural Research Institute, Chakwal during 2006-07. This variety was approved by Punjab Seed Council during the year 2009 for general cultivation in rainfed areas. BARS-09 is shorter in height (95-98 cm), takes 160-175 days to mature, medium in ear size, has high tillering capacity (480/cm²) and 41.17 g 1000-grain weight. The variety performs better at seed rate of 100 kg and NPK dose of 90-60-30 kg per hectare. It has also shown tolerance against drought and leaf/yellow and stem rusts. It would be a good choice to boost up the wheat production particularly in barani areas of the Punjab.

KEYWORDS: *Triticum aestivum*; high yielding variety; disease resistance; rainfed farming; Punjab.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is cultivated both in irrigated and rainfed areas in Pakistan as major food commodity. It contributes 13.1 percent to value

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added in agriculture and 2.7 percent to GDP of Pakistan. Punjab province contributes 75.7 percent towards area and 76.8 percent towards national wheat production. During the year 2009-10 wheat was grown on the area of 6913.5 thousand hectares in Punjab with 17919 thousand tons production. The barani tract covered an area of 549.1 thousand hectares (8%) with 431.3 thousand tons (2.40%) wheat production in the province (7). To meet ever-increasing demand of food grains for rapidly growing population, it is imperative to develop genotypes having better yield potential per unit area especially under water stress conditions. Drought and rusts (leaf and yellow) are the major stresses in rainfed areas of Pakistan causing 30-40 percent loss to wheat crop (2). Chemical control of rust diseases is expensive; so development of rust resistant varieties is of paramount importance (6). Successive release of rust resistant varieties in Pakistan has reduced losses caused by rust (16). However, new rust races also develop due to mutations which result in breakdown of resistance of a variety and it becomes susceptible to various diseases after 5-7 years of its release (15). The favorite high yielding commercial wheat varieties such as Inqalab-91 and Bhakkar-2002 have become susceptible to rust diseases and need to be replaced with new varieties (6). Therefore, there is always need to develop new cultivars possessing wide genetic base with disease resistance, better adaptability and potential of high yield under various agro-climatic conditions. Development of high yielding genotypes having good combination of all yield components would be helpful in improving the yield per unit area significantly (15). Wheat varieties having higher plant growth rate, chlorophyll content, high tillering capacity and 1000- grain weight are more suitable for cultivation under moisture stress conditions (3, 21).

Soil evaporation is main source of water loss, and losses upto 60 percent of seasonal evapotranspiration have been reported (11). These losses may be reduced by using genotypes with good early ground cover (25). High tillering and faster leaf area development in early season result in greater early season ground cover which is an important factor for attaining good yields in low rainfall environments (11, 23). Vigorous early growth and good cover not only significantly reduce water loss from soil due to evaporation but also helps control of weeds. Crop ground cover is inversely related to weed ground cover and associated with the light interception of crop i.e. the more ground covered by the crop, the more shading and the higher the weed suppression (12). Hoard *et al.* (14) reported that an early prostrate habit alongwith a moderate to high leaf area index (through fast leaf development or good crop stand) could efficiently reduce weed growth and appears to be a good marker of competitive ability of a variety. Lanning *et al.* (17) also

showed that wheat and barley varieties with high tillering capacity exhibited better weed control.

The Barani Agricultural Research Station (BARS), Fatehjang is located in the barani area of Punjab. Its mandate is to develop high yielding, disease resistant, broadly adaptable and good quality wheat varieties suitable for farmers of rainfed areas of Punjab. The wheat breeding programme at BARS Fatehjang utilizes genetic variability by crossing genotypes from existing germplasm or select desirable recombinants directly from Semi Arid Wheat Screening Nursery (SAWSN) received from International Maize and Wheat Improvement Center (CIMMYT) Mexico. The present paper describes the performance and evaluation of a high yielding, rust resistant and drought tolerant genotype selected from SAWSN and approved under the name "BARS-09" Punjab Seed Council in its 60th meeting held on May 19, 2009 for general cultivation in the barani tract of Punjab province.

MATERIALS AND METHODS

The BARS-09 is an introduction from 16th Semi Arid Wheat Screening Nursery comprised 174 entries received from International Maize and Wheat Improvement Centre (CIMMYT), Mexico during 1998-99. The screening nursery was planted in single row of 5m length and experiment was set in augmented fashion using Chakwal-86 as local check. During 1999-2000, the line 99FJ03 was evaluated in preliminary wheat yield trial comprising 14 entries alongwith Inqalab-91, Kohsar-95 and Kohistan-97 as checks in RCBD with three replications and a plot size of 5m x 0.9m (3 rows with 30cm spacing). It was further tested in adaptation wheat yield trial during 2000-01 comprising 19 entries including Inqalab-91, Kohistan-97 and Chakwal-97 as check varieties in RCBD with three replicates and a plot size of 5m x 0.9m. In 2001-02, it was tested in station wheat yield trial comprising 12 entries alongwith Inqalab-91, Kohsar-95 and Chakwal-97 as checks. The trial was sown in RCBD with three replications and a plot size of 5m x 1.2m and row spacing of 30 cm (4 rows). During 2002-03, the line 99FJ03 was evaluated in regular wheat yield trial in RCBD with three replications and a plot size of 5m x 1.8m (6 rows with 30 cm spacing). The trial comprised 8 entries including three checks (Inqalab-91, Kohsar-95 and Chakwal-97). It was then sent to Barani Agricultural Research Institute, Chakwal for evaluation in micro wheat yield trial during 2003-04 at eight locations (Chakwal, Piplan, Kot Naina, Kunjah, Dinah, Islamabad, Fatehjang and Attock) in Punjab under rainfed conditions. This trial comprising 18 entries including four checks (GA-2002, Rawal-87, Inqalab-91 and Chakwal-97) was sown in RCBD with three replications and a plot size of 5m x 1.8m (6 rows with 30 cm spacing).

Later, candidate line 99FJ03 was tested for yield, drought and rust resistance in national uniform wheat yield trials (NUWYT) organized by National Coordinator (Wheat), NARC, Islamabad at 17 locations in Pakistan during 2005-06 and 2006-07. Layout system was RCBD with four replications and a plot size of 5m x 1.8m (6 rows with 30cm spacing). This line was screened for its disease response by Crop Disease Research Programme (CDRP) during the years 2005-06 and 2006-07. It was also screened against stem rust at Kenya during 2007-08. Agronomic trials were conducted during 2005-06 and 2006-07 at Fatehjang to find out optimum seed rate, sowing time and fertilizer dose for this candidate line. Layout system of these trials was split plot design. All recommended agronomic practices were applied in all trials. Data recorded were analyzed using standard statistical methods (24). Quality parameters of the line were also assessed by National Agricultural Research Centre (NARC), Islamabad according to standard methods set by American Association of Cereal Chemists (4) and International Association for Cereal Science and Technology (8) following Helrich (13). Various steps involved in the development of BARS-09 are summarized in Table 1.

Table 1. Developmental history of wheat variety BARS-09.

S. No.	Year	Name of trial
1	1998-1999	16 th Semi arid wheat screening nursery
2	1999-2000	Preliminary wheat yield trial
3	2000-2001	Adaptation yield trial
4	2001-2002	Station wheat yield trial
5	2002-2003	Regular wheat yield trial
6	2003-2004	Micro wheat yield trial (rainfed) at 8 locations in Punjab
7.	2005-2006	(a). National uniform wheat yield trials (rainfed) at 17 locations (b). National wheat disease screening nursery, Crop Disease Research Programme, NARC Islamabad (c). Agronomic trials
8.	2006-2007	(a). National uniform wheat yield trials (rainfed) at 17 locations (b). National wheat disease screening nursery, Crop Disease Research Programme, NARC Islamabad (c). Agronomic trials

RESULTS AND DISCUSSION

The foremost objective in the development of BARS-09 was to introduce the farmers of rainfed areas of Punjab a high yielding, drought tolerant and rust resistant variety of wheat. This variety was developed using standard breeding and evaluation procedures. The selected genotype proved to be high yielding and rust resistant and was tested in a series of replicated trials

before putting it into a National yield testing system that is mandatory for the release of a variety in Pakistan. Many varieties in Pakistan were developed using similar breeding approaches (2, 9 & 15).

Evaluation in screening nursery (1998-99)

Among 174 exotic lines planted at BARS, Fatehjang, line 99FJ03 (Entry No. 18) from the cross “PFAU/SERI//BOW” with pedigree “CM85295-101TOPY-2M-0Y-0M-3Y-0M-0SY” produced higher grain yield (2105 kg/ha) exhibiting resistance against yellow and leaf rust diseases under rainfed conditions. The line produced 14.28 percent higher yield than the local check variety Chakwal-86 (1842 kg/ha). Previously a number of wheat varieties such as NARC-09 (2), Manthar-03 (15), NRL 2017 (9) and NIFA Bathoor-08 (18) have also been selected from exotic germplasm introduced from CIMMYT and ICARDA.

Preliminary wheat yield trial (1999-2000)

In preliminary yield trial, 99FJ03 was tested alongwith 14 lines. This line got 3rd position with higher grain yield (4889 kg/ha) than check varieties Kohistan-97 (4370 kg/ha), Inqalab-91 (4370 kg/ha) and Kohsar-95 (4667 kg/ha) (Table 2a). The data showed that 99FJ03 gave 4.75 percent higher grain yield than Kohistan-97 and 11.87 percent higher than both Inqalab-91 and Kohsar-95 (Table 2b). Several earlier workers (2, 9, 15) reported higher yield in new wheat varieties than checks in various yield trials.

Table 2a: Yield performance (kg/ha) of 99FJ03 (BARS-09) in different trials.

Varieties	Preliminary yield trial (1999-2000)	Adaptation yield trial (2000-01)	Station yield trial (2001-02)	Regular yield trial (2002-03)	Average
99FJ03 (BARS-09)	4889	2370	1495	3120	2969
Inqalab-91	4370	1705	977	2200	2313
Kohsar-95	4667	-	1120	2714	2834
Kohistan-97	4370	1750	-	-	2040
Chakwal-97	-	1917	1126	2596	1880
LSD (0.05)	509	433	369	401	

Table 2b. Relative (%) yield increase of BARS-09 over check varieties in yield trials.

Check varieties	Percent increase over checks			
	Preliminary yield trial (1999-2000)	Adaptation yield trial (2000-01)	Station yield trial (2001-02)	Regular yield trial (2002-03)
Inqalab-91	11.87	39.00	53.01	41.42
Kohsar-95	4.75	-	33.48	14.95
Kohistan-97	11.87	35.42	-	-

Chakwal-97	-	23.63	32.77	20.18
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Adaptation wheat yield trial (2000-01)

Among 19 entries line 99FJ03 produced the highest yield (2370 kg/ha) in adaptation yield trial conducted at BARS, Fatehjang with 39.00, 35.42 and 23.63 percent higher yields than check varieties Inqalab-91(1705 kg/ha), Kohistan-97(1750 kg/ha) and Chakwal-97 (1917 kg/ha), respectively (Table 2 a&b).

Station wheat yield trial (2001-02)

In station wheat yield trial conducted at BARS Fatehjang, 99FJ03 topped in yield among 12 entries. It produced 53.01, 33.48 and 32.77 percent higher than checks Inqalab-91, Kohsar-95 and Chakwal-97, respectively (Table 2b).

Regular wheat yield trial (2002-03)

In this trial also line 99FJ03 excelled in grain yield (3120 kg/ha) and produced 41.42, 20.17 and 14.95 percent higher than check varieties Inqalab-91 (2200 kg/ha), Chakwal-97 (2596 kg/ha) and Kohsar-95 (2714 kg/ha), respectively (Table 2a & b).

Micro wheat yield trial (rainfed, 2003-04)

During 2003-04, line 99FJ03 was evaluated alongwith 17 other lines/entries (contributed by other breeding institutes) in micro wheat yield trial at eight locations under rainfed conditions of Punjab. This line stood second in average grain yield (3437 kg/ha) which was 8.73, 3.62 and 1.53 percent higher than Rawal-87 (3161 kg/ha), Inqalab-91(3317 kg/ha) and Chakwal-97 (3385 kg/ha), respectively (Table 3). Similar results were reported by Ahmad *et al.* (2).

Table 3. Grain yield performance of 99FJ03 (BARS-09) in micro yield trial (2003-04).

Locations	Mean grain yield (kg/ha)				LSD (0.05)	CV (%)
	99FJ03 (BARS-09)	Inqalab-91	Chakwal-97	Rawal-87		
BARI, Chakwal	4917	2383	3361	2806	516	7.2
Piplan	4556	3528	3956	3783	432	6.2
Kot Naina	2963	3200	2500	3433	776	16.1
Kunjah	2306	1767	1706	1689	197	5.6
Dinah	1917	1819	1847	1928	250	7.5
NARC, Islamabad	1000	1050	1133	1133	621	10.1
BARS, FatehJang	3133	3067	1967	2367	641	10.1
GRS, Attock	2972	3067	3406	3139	581	10.4
Mean	3437	3317	3385	3161	-	-
Increase over	-	3.62	1.53	8.73		

check (%)

National uniform wheat yield trials (rainfed) (2005-2007)

Due to high yield potential, disease resistance and other agronomic attributes, the line was included in national uniform wheat yield trials coordinated by NARC, Islamabad during the year 2005-06 and 2006-07. During 2005-06, line 99FJ03 was tested at 17 locations throughout Pakistan including 9 locations in Punjab province. Yield data (Table 4) showed that line 99FJ03 got 6th position in Punjab (2821 kg/ha) and produced 6.21 percent higher grain yield than composite local check. Similar findings were reported by Mustafa *et al.* (19).

Table 4. Performance of 99FJ03 in national uniform wheat yield trial (rainfed), 2005-06.

Genotypes	Grain yield (kg/ha) in Punjab (9 locations)										Avg. yield	increase over check (%)
	Attock	NARC Isd	BARS, F/Jang	BARI, Chakwal	Gujar Khan	Piplan	Kot Nainan	Kunjah	Bhimber			
99FJ03	1325	3490	2813	3192	3292	3579	2014	2392	3300	2821	6.21	
Local check	2009	3198	3148	2667	2217	3097	2073	1792	3298	2656		
LSD (0.05)	194	NS	471	585	631	748	NS	516	NS	200.5		

In NUWYT (2006-07), 99FJ03 performed excellently and stood third both in Pakistan (17 locations) and Punjab (8 locations). On average basis it produced higher (4008 kg/ha) in Punjab; 21.42 percent higher than composite local check (Table 5). Similar results were reported by Mustafa *et al.* (20).

Table 5. Performance of 99FJ03 in national uniform wheat yield trial (rainfed) 2006-07.

Genotypes	Grain yield (kg/ha) in Punjab (8 locations)									Average yield	Increase over check (%)
	CRS, Piplan	NARC, Isd	BARS, F/Jang	BARI, Chakwal	Chakwal Bhuan	PSC Farm, Piplan	Kot Nainan	Kunjah			
99FJ03	3240	4116	3978	5613	4807	3958	2888	3465	4008	21.42	
Local check	2067	3017	3714	4245	3732	3729	2907	2595	3301		
LSD (0.05)	807	488	770	834	573	324	168	598	209		

The two years evaluation of BARS-09 over multiple locations confirmed the results of on-station trials. It is concluded that BARS-09 gave better grain yield and tolerance against rust diseases as compared to existing varieties. It was also observed that with overall good performance, this variety is better adaptable to various climatic conditions of Punjab and Pakistan (19, 20).

Disease reaction

The candidate line 99FJ03 was also evaluated for its response against yellow and leaf rust diseases. It was found resistant to both rusts during 2005-06 and 2006-07 (22). According to data provided by the Crop Disease Research Programme (CDRP), Islamabad, the line 99FJ03 showed a desirable relative resistance index (RRI) of 9 and 7.1 for yellow rust (YR) and 5 and 9 for leaf rust (LR) (Table 6). Acceptable RRI is 5, whereas desirable RRI for leaf and yellow rusts is 7 and above. Similar findings were reported by Afzal *et al.* (1).

Table 6. Response of 99FJ03 (BARS-09) to yellow and leaf rusts in Pakistan.

Location	Leaf rust		Yellow rust	
	2005-06	2006-07	2005-06	2006-07
CCRI, Pirsabak	-	-	0	5S
NIFA, Peshawar	-	-	0	10S
NARC, Islamabad	-	-	5MS	5S
AARI, Faisalabad	-	0	-	0S
RARI, Bahawalpur	20S	0	-	-
CDRI, Karachi	-	0	-	-
NIA, Tandojam	-	0	-	-
WRI, Sakrand	-	0	-	-
AJK	5MS	-	-	-
RRI (Relative Resistance Index)	5	9	9	7.1

Rust disease of wheat damages the quality of grain in addition to yield reduction. Therefore, grains obtained from susceptible varieties grown under diseased conditions are of inferior quality having reduced grain protein, gluten, test weight, PSI and 1000- kernel weight. In contrast, the resistant varieties produce better yield and grains of better quality (15). A number of researchers developed new wheat varieties having better resistance against rust diseases compared to check varieties (2, 9, 15, 18). The line 99FJ03 was also evaluated for stem rust (UG99) resistance in Kenya in 2007. The results indicated that it is stem rust tolerant (5MR to 15MSS) with remarks of 1st choice (Table 7).

Table 7. Response of 99FJ03 to stem rust (UG99) in Kenya during 2007.

Name of entry	Sowing date 1 (26-09-2007)	Sowing date 2 (29-09-2007)	Sowing date 3 (03-10-2007)	Remarks
99FJ03	5MR	10 MSS	15MSS	1st choice

Agronomic trials

Agronomic trials were conducted at BARS, Fatehjang during 2005-06 and 2006-07 to find out optimum planting time, seed rate and fertilizer requirement for the candidate line under rainfed conditions. The results of sowing date trial revealed that 99FJ03 gave higher yield when sown from 20th

October to 5th November than other sowing dates. Therefore the best recommended sowing time for this variety ranged from end October to first week of November (Table 8). Ahmad *et al.* (2) also reported end of October to first week of November as best sowing time for newly developed wheat genotype NARC-09 in barani tract of Punjab.

Table 8. Effect of various sowing dates on grain yield of 99FJ03 (BARS-09).

Year	Grain yield on different sowing dates			
	20 th Oct.	5 th Nov.	20 th Nov.	5 th Dec.
2005-06	3517	3484	2687	2288
2006-07	3894	3680	3644	3528
LSD (0.05) 2005-06 = 48.1, LSD (0.05) 2006-07 = 73.8				

The results of seed rate trial for both years indicated that maximum yield of 99FJ03 (2648 kg/ha during 2005-06 and 4240 kg/ha during 2006-07) was obtained when the seed was used @ 100 kg per hectare (Table 9). Similar findings were reported by Ahmad *et al.* (2) for newly developed wheat cultivar NARC-09.

Table 9. Average grain yield of 99FJ03 (BARS-09) as affected by various seed rates.

Year	Grain yield with different seed rates (kg/ha)			
	75	100	125	150
2005-6	2552	2648	2133	2129
2006-07	100	125	150	175
	4240	3831	4140	4090
LSD (0.05) 2005-06 = 110.4, LSD (0.05) 2006-07 = 91.8				

In order to determine the fertilizer requirements of new wheat genotype 99FJ03 under rainfed conditions, different doses of fertilizer were applied at sowing. NPK @ 90- 60 -30 kg per hectare gave better yield (Table 10).

Table 10. Effect of fertilizer on grain yield of 99FJ03 (BARS-09).

S. No.	Fertilizer dose (kg/ha)			Grain yield (kg/ha)	
	N	P	K	2005-06	2006-07
1	0	0	0	3198	4050
2	30	60	30	3557	4511
3	60	30	30	3779	4727
4	90	60	30	3817	5311
5	120	90	60	3842	5338
LSD (0.05) 2005-06 = 64.0, LSD (0.05) 2006-07 = 48.2					

Quality characteristics of BARS-09

Seed quality is an important parameter that determines the acceptability of a commodity among the consumers (10).The candidate line 99FJ03 was also

evaluated for quality parameters *i.e.* 1000- kernel weight, test weight, PSI, grain ash, grain protein, gluten consistency, wet gluten and dry gluten for two years (Table 11). Grains of 99FJ03 are medium bold with high gluten contents. Moreover, the grain has high protein contents and possesses very good chapatti/bread making quality. These results are in accordance with those of Mustafa *et al.* (19, 20).

Table 11. Quality traits of 99FJ03 (BARS-09).

S. No.	Quality traits	2005-06	2006-07
1	1000-grain weight. (g)	40.6	41.17
2	Grain ash (%)	1.2	1.307
3	Grain protein (%db)	10.7	13.12
4	Gluten consistency	S	S-MS
5	Wet gluten (%)	23.0	29.98
6	Dry gluten (%)	7.5	9.89
7	Chapatti quality	Very good	Very good
8	Test weight (kg/hl)	77.2	78.80
9	PSI	41	39

Salient features of variety BARS-09 (99FJ03)

BARS-09 is a semi-dwarf (95-98 cm) variety, shorter in height than Chakwal-97 and GA-2002. Plant is erect with prostrate habit and has medium wax. Number of days for 50 percent heading are 120-130 while days to 50 percent maturity are 160-175, so it is a medium duration genotype. It produces large number of productive tillers (480/m²). Stem is stiff as compared to GA-2002 and has 3-4 nodes per stem. Leaves are planophile. Ear is slightly tapering, medium lax and 10-12 cm long. Glume shoulder shape is square. Rachis is long (9-11cm) with 18-20 segments. Awn colour is yellowish white as compared to white in Chakwal-97. Beak is medium in size and straight in shape. Seed colour is amber, seed brush is short. Its seed is medium bold in size (41.17 g) with 6-8 mm length, 3-4 mm width and 2-3 mm thickness.

This variety has high level of resistance against lodging and shattering. It has also shown good performance under moisture and freezing stress conditions. It has desirable features of early ground cover, high growth rate and high tillering capacity, best suitable for low rainfall areas as already reported by various research workers (3, 11, 21, 23, 25). Further, weeds are big problem in barani areas as weedicides can only be used at proper moisture level which is difficult to achieve in these areas. BARS-09 has the ability to suppress weeds as crop ground cover is inversely related to weed ground cover and associated with the light interception of crop *i.e.* the more ground

covered by the crop, the more shading and the higher the weed suppression (12). Hoad *et al.* (14) also confirmed that an early prostrate growth habit combined with greater leaf area index of a variety is helpful in suppressing weed growth. High number of tillers and faster leaf area development of this variety (BARS-09) early in the season boost the production of biomass and results in greater early season ground cover, which is an important feature for better production in low rainfall environments as earlier reported by other research workers (11, 25). BARS-09 produces large number of tillers /m², so less seed rate (100 kg/ha) is sufficient for this variety as compared to 125 kg for other varieties. Greater number of tillers/m² also compensates the loss occurred due to less germination caused by variable moisture conditions in comparatively less leveled fields of barani areas and also helps control weed as reported by Lanning *et al.* (17).

This variety was approved by the Punjab Seed Council during the year 2009 for general cultivation in barani tract of Punjab. Before the release of this cultivar only few varieties of wheat i.e. Chakwal-50 and GA-2002 were available for barani tract of Punjab. BARS-09 is not only high yielder but also possesses high level of resistance against rusts.

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