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Fakhar-E-Bhkkar - A high yielding, temperature stress tolerant and rust resistant spring bread wheat variety

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Abstract

A new wheat variety (Fakhar-E-Bhakkar), high yielding, temperature stress tolerant and disease resistant was developed by hybridization between strain 93T347 and commercial cultivar Auqab-2000 at Arid Zone Research Institute, Bhakkar, Pakistan. F_2 to F_6 generations of this cross were advanced by modified bulk pedigree method from 2004 to 2010. Flag leaf attitude is semi erect and auricle color is white. This variety has tapering head shape with 13-14 cm length having 21-22spikelet per spike. It has high tillering capacity (145tillers per meter row).Fakhar-E-Bhakkar has good yield potential in poor sandy soil, early & terminal heat stress environments and characterized with morphological marker of anthocyanin pigmentation at peduncle and awns during grain filling stage. One thousand kernel weight ranges from 40.00 to 45.00 g. Seed is ovate, medium and amber in color having protein content 15.00%. It has good chapatti making quality. New wheat variety Fakhar-E-Bhakkar is resistant to prevailing races of leaf and yellow rusts along with desirable tolerance against local race of stem rust. It was approved for commercial cultivation in hot irrigated dry climate of Punjab, Pakistan.

Keywords: *Triticum aestivum*; crossbreeding; new cultivar; disease resistance; anthocyanin; Pakistan.

Introduction

Wheat (*Triticum aestivum* L.) is staple food grain of Pakistan, supplying 72% of calories and protein in the average diet. It occupies 70% of Rabi and 37% of the total cropped area in the country. Per capita wheat consumption per year is 125 kg. The wheat straw is also very important as livestock feed(Anonymous, 2010-17).Wheat crop is mostly planted in irrigated condition that shares 91 % of the total area under cultivation of the Punjab. However, 9% wheat crop area of Punjab is cultivated in rainfed condition. Irrigation sources are canal water and underground water (tube wells) for good crop yield in irrigated areas(Anonymous, 2015-16). Farmers are facing many problems like heat stress (Early and terminal), diseases, water shortage and Insect pests etc. Enshrined aim of wheat breeding is to change the hereditary to combat with the potential problems being faced by the farmers of southern Punjab.

Farmers prefer wheat varieties with high yield potential. Fakhar-e-Bhakkar displayed maximum yield 6.7 tons per hectare during the course of experimentation. The new variety was developed at Arid Zone Research Institute Bhakkar working under the overall patronage of AARI Faisalabad. This variety also displayed better yield performance in sandy and poor soil condition. Disease incidences especially yellow and brown are live problems, which

alter time to time rapidly. This strain also showed resistance against major diseases of wheat i.e. Yellow Rust (*Puccinia striiformis*), Leaf Rust (*Puccinia triticina*) and Stem Rust (*Puccinia graminis*).

Fakhar-e-Bhakkar was also tested in sandy soil and early planting environment and exhibited encouraging results. As concerned quality, protein % is high as upto 15% with desirable gluten. Resultantly commercial cultivation of this variety will enhance the existing wheat yield potential at farmer's field level of Punjab.

Materials and Methods

A new variety (Fakhar-E-Bhakkar) was developed by local cross between wheat advance line 93T347 and Auqab-2000. Hybridization was done during 2003-2004 at Arid Zone Research Institute, Bhakkar (Punjab), Pakistan. After passing successive generations, it became homogeneous in F6 generation (Table 1, 2). On the basis of its plant type, number of tillers, spike length, number of grains per spike and resistant type reaction to yellow rust (YR) and leaf rust (LR), this inbred was selected for testing in replicated trials using RCBD. The selected line was tested in micro wheat yield trials (timely & late planting) during 2013-14. It was planted over 19 different locations throughout the Punjab province. The sowing of timely planting trial was done during the first fortnight of November and the sowing of late planting trials was done in the first fortnight of December. The plot size was 6 m^2 keeping four rows 25 cm apart. All the agronomic practices were kept constant. The variety later was further tested at national level for two consecutive years from 2014-16. At maturity, individual plots were harvested and the yield per plot was recorded. The data were analyzed through computer software MSTAT (Steel and Torrie, 1984). Beside this, the variety Fakhar-E-Bhakkar was also tested in local as well as in national disease screening nurseries during the study period for four consecutive years (2012-13, 2015-16).

Test entries were planted in a single row of 2 meter including Fakhar-E-Bhakkar. Morocco was planted as susceptible check. Artificial inoculation was done with a mixture of prevailing rust races. The data were recorded for leaf and yellow rusts as percent infection on plants according to the modified Cobbs scale (Peterson *et al*., 1948).

Table:1. Development history of Fakhar-E-Bhakkar.

Sr. No.	Year	Generation/ Trial
1.	2003-04	Hybridization
2.	2004-05	F_1
3.	2005-06	F_2
4.	2006-07	F_3
5.	2007-08	F_4
6.	2008-09	F_5
7.	2009-10	F_6
8.	2010-11	A-TRIAL
9.	2011-12	B-TRIAL
10.	2012-13	RWYT
11.	2013-14	PUWYT
12.	2014-15	NUWYT
13.	2015-16	NUWYT

Results and Discussion

1. On station and regional level testing:

The data represented in (Table 2) revealed that in the preliminary and regular yield trials the variety Fakhar-E-Bhakkar on an average basis produced 7 and 12 percent higher yield respectively in comparison with check varieties Punjab-11 and FSD-08. Similarly in regional wheat yield trial (Table 3) percent increase in yield over the check varieties was 7 and 4.5 percent. Therefore, it was promoted to the Micro/regional Trialsduring 2013-14.

Table: 2. Yield performance of Fakhar-E-Bhakkar in station yield trials.

Year of testing	Name of Trial	Yield (Kg ha^{-1})		
		Fakhar-E-Bkr	Punjab-11	FSD-08
2010-11	A-Trial	**5794**	-	5238
2011-12	B-Trial	**5917**	5472	-
Average		**5855**	5472	5238
% Increase over check			**7**	**12**

Table: 3.Yield performance of Fakhar-E-Bhakkar in Regional Wheat Yield Trials (2012-13)

Location	Yield Kg/ha		
	Fakhar-E-Bkr	Punjab 11(Check)	FSD-08(Check)
ARS Karor	**4625**	4395	4415
PSC Farm Piplan	**4815**	4550	4535
AZRI Bhakkar	**5506**	4950	5310
GRSS. Kallurkot	**4800**	4625	4640
Mean	**4941**	4630	4725
% Increase over check		**7**	**4.5**

2. Provencial level testing:

The wheat variety Fakhar-E-Bhakkar was planted at 33 different locations in timely (15 locations) and late (18 locations) planting regimes in all over Punjab during 2013-14. It produced 7 & 4percent higher yield (4179 kg ha^{-1}) than check varietiesPunjab-11 and FSD-08 in timely planting while in late planting it produced 6 & 3 percent higher yield(3622kg ha^{-1}) in comparison with check varieties Millat-11 and Lasani-08 respectively. Fakhar-E-Bhakkar produced 5272 and 5226 kg ha^{-1} at Khanewal and Lodhran, in timely planting while it produced 4841 and 4617kg ha^{-1} at Bahawalnagar and ARS, Karor, respectively in late planting. Due to its better performance in the zonal trials, it was promoted to NUWYT trials for its testing at Pakistan level for adaptability and other agronomic characteristics.

Table: 4. Yield performance of wheat variety Fakhar-E-Bhakkar in PUWYT(Timely&Late Planting) during 2013-14.

Sr. No.	Location	Timely Planting (Kg/ha)			Late Planting (Kg/ha)		
		Fakhar-E-Bkr	Punjab-11	FSD-08	Fakhar-E-Bkr	Millat-11	Lasani-08
1	AZRI, Bhakkar	**3633**	3033	3567	**3667**	3567	2667
2	GRSS Piplan.	**4594**	4462	4263	**3708**	3317	4487
3	ARF Karor	**3836**	3384	3778	**4617**	4951	4595
4	Alipur, M. Garh	**4300**	4200	3267	**3167**	3000	3167
5	Feroza.R.Y. Khan	**3500**	3300	2800	**2633**	2957	2533
6	RARI BWP	**2947**	2563	3133	**2907**	2443	2910
7	Bahawalnagar	**3987**	3853	3874	**4841**	4478	4346
8	Lodhran	**5226**	4648	5323	**4484**	3881	4637
9	ARF Vehari	**4559**	4116	4356	**4300**	3575	4011
10	Multan	**4826**	4751	4700	**3678**	3366	3674
11	PSCFarmKhanewal	**5272**	5051	5258	**2953**	2979	2564
12	AARI, FSD	**4444**	4094	3722	**3750**	3172	3506
13	Okara	**3696**	3661	4260	-	-	-
14	MMRI, Sahiwal	**3903**	3393	3729	**4290**	4574	4271
15	Dhakkar	**3967**	3778	4248	**3528**	3350	3471
16	RRI KSK	-	-	-	**4459**	4111	4966
17	ARS, Gujranwala	-	-	-	**2346**	1868	2107
18	Kotnaina	-	-	-	**2596**	2787	2130
19	FRI,Sargodha	-	-	-	**3263**	3206	3039
Mean		**4179**	**3886**	**4019**	**3622**	**3421**	**3505**
% Increase Over Check			**7**	**4**		**6**	**3**

3. National level testing (2014-15):

The data indicated that Fakhar-E-Bhakkar produced 6.0, 4.0, 5.0, 10 and 5.0 percent higher yield than FSD-08, Galaxy, Pak-13, Ehsan-16 and Jouhar-16 in irrigated condition in 19 different locations (Table 5.1) while it gave 1.0, 8.0, 9.0, 4.0 and 5.0 percent higher yield than four check varieties viz Pak-13, Dharrabi-11, FSD-08, Jouhar-16 and Ehsan-16 at 7 locations in rainfed condition (Table 5.2)during 2014-15 respectively. Fakhar-E-Bhakkar produced maximum grain yield (5222 kg ha^{-1}) at Fort Abbas and minimum (3012 kg ha^{-1}) at ARF, Gujranwala in irrigated conditions and maximum yield (6667 kg/ha) at BARS, Fathejang and minimum (2938 kg ha^{-1}) at AZRI, Bahawalpur in rainfed condition.

Table: 5.1Yield performance of Fakhar-E-Bhakkarin NUWYT (Irrigated) during 2014-15.

Sr. No.	Location	Irrigated (Kg/ha)					
		Fakhar-E-Bkr	FSD-08	L. check	Pak-13	Ehsan-16	Johar-16
1	AZRI Bhakkar	**4825**	4700	4650	4400	4600	4450
2	GRSS, Kal. Kot	**3701**	3687	3910	3411	2701	3985
3	ARF, Karor	**3297**	3426	3509	3233	2835	3292
4	Alipur.MZG	**5106**	4278	3500	3611	3389	4389
5	DG Khan	**4000**	4667	4112	3889	5000	4034
6	MozaKikri RYK	**4734**	4727	4775	3946	4962	3868
7	PSCF Khanewal	**3224**	3609	3737	3882	3085	3774
8	Jahanian, Multan	**4225**	2446	3565	4171	3011	4025
9	Jalla A. Lodhran	**4563**	3728	3450	4833	3720	4701
10	Fort Abbas	**5222**	4000	4611	3656	4056	3334
11	RARI,BWP	**3631**	3546	2819	3801	3280	3573
12	RSS B.Nagar	**4374**	3670	3987	3570	3621	3348
13	ARF, Gujranwala	**3012**	3210	3035	3047	3150	2987
14	Dhakkar	**3829**	3830	4111	3502	3355	4117
15	IATI, Sargodha	**4129**	4032	4919	4238	4025	4217
16	RRI,KSK	**3018**	2479	3106	2963	2965	2965
17	MMRI, Sahiwal	**3842**	3856	3576	4176	4029	4418
18	Okara	**3998**	3839	3379	4591	3665	3263
19	AARI, FSD	**4550**	4848	5543	4590	4426	4657
Mean		**4067**	**3820**	**3910**	**3869**	**3678**	**3863**
% Increase over checks			**6**	**4**	**5**	**10**	**5**

Table: 5.2Yield performance of Fakhar-E-Bhakkarin NUWYT (Rainfed) during 2014-15.

Sr. No.	Site/ location	Rainfed (Kg/ha)					
		Fakhar-E-Bkr	Pak-13	Dharrabi-11	FSD-08	Johar-16	Ehsan-16
1	BRSS,Piplaan	**3538**	3120	3033	3667	3923	3089
2	AZRI,BWP	**2938**	2353	2344	2068	3165	2613
3	BARI,Chakwal	**5307**	5756	5653	4858	4222	5067
4	ARF,Bhaun	**5006**	5609	5259	4829	4872	5387
5	GRSS,Attock	**3980**	4119	3746	3786	3531	3791
6	BARS,Fatehjang	**6667**	6389	5123	5648	6544	6451
7	WRI,FSD	**4825**	4586	4617	4647	4751	4222
Mean		**4608**	**4561**	**4253**	**4214**	**4429**	**4374**
% Increase over checks			**1**	**8**	**9**	**4**	**5**

4. National level testing (2015-16):

Fakhar-E-Bhakkar displayed 5.0, 6.0, 5.0 and 9.0 percent higher grain yield than three check varieties viz. FSD-08, Pak-13 and Jouhar-16 in 18 different locations (Table 6.1) in irrigated regime while new wheat variety produced 1.0 and 9.0 percent higher yield than two check varieties FSD-08 and Jouhar-16in rainfed condition (Table 6.2). Fakhar-E-Bhakkar produced maximum grain yield at RARI, Bahawalpur (5426 kg ha^{-1}) while minimum at Govt. Seed Farm, Pakpatan (2650 kg ha^{-1}) in irrigated condition, however it produced maximum yield (4957 kg ha^{-1})in rainfed regime at BARI, Chakwal and minimum grain yield (2406 kg ha^{-1}) at CRSS, Piplan.

Table: 6.1Yield performance of Fakhar-E-Bhakkarin NUWYT during 2015-16 (Irrigated).

Sr. No.	Site/ location	Irrigated (Kg/ha)				
		Fakhar-E-Bkr	L. Check	FSD-08	Pak-13	Johar-16
1	CRS, Multan	**4344**	4090	3737	5375	4224
2	R.Y.Khan	**3757**	4439	5416	2750	4703
3	F.AbbasB.nagar	**5212**	4160	3950	3784	3810
4	RARI,BWP	**5426**	4058	4852	3352	5110
5	PSC,Khanewal	**4064**	4596	3647	4553	4220
6	Alipur	**5049**	4737	3234	4068	4719
7	ARS,Karor	**4259**	3607	3405	3454	3734
8	RSS,B.Nagar	**3614**	3046	2907	3370	2022
9	GSS,K.Kot	**4783**	3622	3740	4537	3532
10	Jahanian,Khanewal	**4509**	4966	3950	4252	3787
11	Lodhran	**4916**	5392	5704	4981	5156
12	AZRI,Bhakkar	**4446**	4055	3825	3825	4550
13	GSF, Pakpatan	**2650**	2493	3938	2676	2991
14	ARS, Sargodha	**3031**	2128	3574	4585	2251
15	RRI, KSK	**2664**	2975	3165	2954	3124
16	MMRI, Sahiwal	**4093**	4292	3399	4357	3890
17	Okara	**3411**	4711	3805	3996	2528
18	WRI, FSD	**3975**	3432	3584	3904	3257
Mean		**4122**	**3933**	**3880**	**3932**	**3756**
% Increase over check			**5**	**6**	**5**	**9**

Table: 6.2 Grain Yield performance of Fakhar-E-Bhakkar in NUWYT (Rainfed) during 2015-16.

Sr. No.	Location	Grain yield (Kg/ha)		
		Fakhar-E-Bhakkar	Faisalabad-08	Johar-16
1	BARI,Chakwal	4957	5139	4414
2	ARF,Bhaun	4127	4000	3859
3	GRSS,Attock	2418	1867	2591
4	BARS,Fatehjang	4688	4519	3903
5	CRSS,Piplan	2406	1996	1574
6	WRI,FSD	3811	4724	4228
Mean		**3735**	**3708**	**3428**
% Increase over check			**1**	**9**

6. Agronomic studies:

Agronomic studies were conducted to determine the best sowing date, seed rate and fertilizer requirements of new wheat variety Fakhar-E-Bhakkar. Relevant data indicated that Fakhar-E-Bhakkar produced comparatively better grain yield in planting window from 5th to 25th November during the study year. Its yield was also higher than check varieties. Fakhar-E-Bhakkar gave maximum yield (5840 kg ha^{-1}) when planted on 10th November and minimum yield (3370 kg ha^{-1}) in 25th December planting during the 1st year of study 2015-16 (Table 7.1). Similarly during the second year of study 2016-17 it displayed maximum yield (5818 Kg ha^{-1}) when planted on 15th November and minimum (3209 Kg ha^{-1}) in 25th December planting (Table 7.2).

Table: 7.1GrainYield performance of Fakhar-E-Bhakkar in sowing date trials during 2015-16.

Sr. No.	Sowing Date	Yield (Kg/ha)		
		Fakhar-E-Bhakkar	FSD-08	Galaxy-13
1	October 25th	**4870**	4430	4260
2	November 10th	**5840**	5530	5235
3	November 15th	**5730**	5573	5620
4	November 25th	**5415**	5370	5220
5	December 5th	**4345**	4513	4410
6	December 15th	**4012**	3945	3890
7	December 25th	**3370**	3065	3410

Table: 7.2Yield performance of Fakhar-E-Bhakkar in sowing date trials during 2016-17.

Sr. No.	Sowing Date	Yield (Kg/ha)	
		Fakhar-E-Bhakkar	Ujalla-16
1	October 25th	**4990**	4653
2	November 5th	**5629**	5384
3	November 15th	**5818**	5447
4	November 25th	**5490**	5362
5	December 5th	**4298**	4518
6	December 15th	**3815**	3795
7	December 25th	**3209**	3370

Fakhar-E-Bhakkar proved well responsive to the fertilizers and it gave maximum grain yield of 4990 kg ha^{-1} treatment 4 fertigation. Therefore, NPK dose of 150-120-60 kg/ha (Table 8) was recommended for realization of maximum grain yield.

Table: 8. Effects of different levels of NPK fertilizers on grainyield of Fakhar-E-Bhakkar.

Sr. No.	Nutrients levels NPK (Kg/ha)			Grain Yield (Kg/ha)
	N	P_2O_5	K_2O	
1	0	0	0	2070
2	0	120	60	2320
3	75	120	60	3780
4	**150**	**120**	**60**	**4990**
5	225	120	60	4804
6	150	0	60	3765
7	150	60	60	4370
8	150	180	60	4930
9	150	120	0	4595
10	150	120	30	4710
11	150	120	90	4730

7. Disease reaction:

Fakhar-e-Bhakkar proved resistant to yellow, brown and stem rusts in NWDSN testing in four years consecutive studies(2012-16) conducted by CDRI Islamabad/Karachi in comparison with Morocco being highly susceptible to three rusts at 11 locations in all over Pakistan. Similarly yellow, brown and stem rusts data indicated that Fakhar-E-Bhakkar showed resistance even in respective rust potential areas in comparison with Morocco.

Table: 9. Leaf rust, yellow rust and stem rust data of CDRI during study years 2012-16.

Sr. No.	Disease	Variety Name	2012-13		2013-14		2014-15		2015-16	
			TR	ACI	TR	ACI	TR	RRI	TR	RRI
1	**Leaf Rust**	Fakhar-E-Bhakkar	5M	**0**	TMR	**0.8**	TMS	**9**	5M	9
		Morrocco	80S	-	90S		90S	-	90S	-
2	**Yellow Rust**	Fakhar-E-Bhakkar	TMR	**1**	5MRMS	**3**	5M	**8**	40M	7.0
		Morrocco	100S	-	90S	-	80S	-	90S	-
3	**Stem Rust**	Fakhar-E-Bhakkar	5M	**2**	5MR	**3**	10 MR	**6**	5M	8
		Morrocco	80S	-	90S	-	90S	-	100S	-

8. Entomological studies:

The data presented in Table 10 revealed that it was comparable to other varieties regarding the presence of aphids. Fakhar-E-Bhakkar was attacked by aphids below economic threshold level thereby having built in tolerance against the aphids. Moreover, it is characterized with morphological marker of anthocyanin pigmentation at peduncle and awns during grain filling stage. Anthocyanin plays its role in repelling aphids (Kevin, 2004; Simcha and Gould, 2008).Therefore, this variety on this account proved unattractive to aphids.

Table: 10. Aphid population studies at AZRI Bhakkar

Sr. No	Variety Name	Av. Aphid/ Tiller	
		2014-15	2015-16
1	**Fakhar-E-Bhakkar**	**10**	**8**
2	Punjab-11	20	21
3	FSD-08	18	17

9. Quality studies:

Quality characteristics of Fakhar-E-Bhakkar are good and data presented in tables (11.1, 11.2) indicated that its protein content ranged from 14.00% to 15.00 %. Similarly thousand grains weight found from 40.00 to 45.00g coupled with good chapatti quality.

Table: 11.1 Quality characteristics of Fakhar-E-Bhakkar at NARC, Islamabad during 2014-15

Sr. No.	Variety Name	1000. G.W (gm)		Test Wt. (Kg/hl)		Starch (%)		Grain Protein (%)		Gluten Wet (%)	
		IRR.	RF	IRR.	RF	IRR.	RF	IRR.	RF	IRR.	RF
1	**Fakhar-E-Bhakkar**	**41**	**42**	**77**	**78**	**55**	**56**	**15**	**14**	**28**	**28**
2	Galaxy-13	42	44	77	77	55	54	14	15	29	32
3	FSD-08	37	40	77	78	52	53	15	13	32	24
4	Pak-13	40	44	76	77	54	55	16	14	32	27

Table: 11.2 Quality characteristics of Fakhar-E-Bhakkar at NARC, Islamabad during 2015-16

Sr. No	Variety Name	1000. G.W (gm.)		Test Wt. (Kg/hl)		Protein (%)		Starch (%)		Gluten Wet (%)	
		IRR.	RF	IRR.	RF	IRR.	RF	IRR.	RF	IRR.	RF
1	**Fakhar-E-Bhakkar**	**38**	**42**	**74**	**80**	**15**	**15**	**55**	**54**	**32**	**31**
2	FSD- 2008	37	39	74	79	15	14	53	48	33	30
3	Pak-13	35	40	74	78	16	14	54	57	33	28

Conclusion

Fakhar-E-Bhakkar a high yielding, temperature stress tolerant and disease resistant hexapliod spring bread wheat variety was developed at Arid Zone Research Institute, Bhakkar for general cultivation in hot irrigated dry climate. Fakhar-E-Bhakkar has good yield potential in poor sandy soil, early & terminal heat stress environments and characterized with morphological marker of anthocyanin pigmentation at peduncle and awns during grain filling stage. Fakhar-e-Bhakkar proved resistant to yellow, brown and stem rusts in NWDSN testing (2012-16) conducted by CDRI Islamabad/Karachi. Fakhar-E-Bhakkar was disliked by aphids and infestation remained below economic threshold level displaying in built pest tolerance.

Quality characteristics of Fakhar-E-Bhakkar were good and indicated that its protein content ranged from 14.00% to 15.00 % with good chapatti quality.

Table: 12. Description of the variety Fakhar-E-Bhakkar

Sr. No.	Character	Range
1	Plant Height (cm)	100-110
2	Growth behavior	Erect
3	Plant color	Green
4	Head color	Yellowish white
5	Straw color	Yellowish white
6	Seed color	Amber
7	Flag Leaf	Semi Erect
8	Auricle Color	White
9	Head shape	Tappering
10	Spikelet's/spike	21-22
11	Days to 50% heading	100-105
12	Days to physical maturity	145-150
13	Protein percentage (%)	15
14	Thousand seed weight (g)	40-45
15	No. of tillers/ meter row	140-145
16	Yield potential	7400 kg/ha
17	Disease reaction	Resistant/ tolerant

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