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CHAKWAL-50: A HIGH YIELDING AND DISEASE RESISTANT WHEAT VARIETY FOR RAINFED REGION

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ABSTRACT

Chakwal-50 a spring wheat (*Triticum aestivum* L.) variety was developed at Barani Agricultural Research Institute (BARI), Chakwal, Pakistan and released in 2008 for general cultivation as high yielding, drought tolerant and disease resistant wheat cultivar for rainfed areas of Punjab, Pakistan. The cultivar was developed by selecting the plants from entry No. 20 of 20th Elite Spring Wheat Yield Trial received from CIMMYT, Mexico during 1999-2000. Selection was done on phenotypic basis and the line was evaluated in various yield trials conducted at Barani Agricultural Research Institute, Chakwal and other ecological zones of the country from 1999 to 2008, based on the desirable traits for drought tolerance (erect, twisted and waxy leaves), diseases tolerance (Yellow rust, Brown Rust & Karnal Bunt) and high grain yield. This line gave significant higher yield than existing varieties like Chakwal-97, Kohistan-97, GA-2002 and Inqilab-91. This line also showed tolerance against yellow rust, brown rust and Karnal bunt. This variety was approved for general cultivation in rainfed areas of the Punjab as "Chakwal-50" by the Punjab Seed Council in its 36th meeting held on 9th July, 2008.

Key words: *Triticum aestivum*; Chakwal 50; Rainfed; Resistance; Rust; Karnal bunt; Yield

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the major food cereal in Pakistan. Most of the wheat in province of Punjab is grown under artificial irrigated conditions through canals or tube wells. However, in the areas where rainfall is sufficient (above 350 mm annually), the wheat crop is sown under rainfed conditions. Rainfed areas account for about 12% of area and 8% of Wheat production in the Punjab. The variety complex undergoes changes in response to biotic and abiotic compulsions Khan *et al*. (2002); Rodf *et al*. (1992). In Pakistan brown rust (*Puccinia recondita*) and yellow rust (*Puccinia striiformis*), Karnal bunt (*Tilletia indica* Mitra) are among the serious diseases of wheat (Haq., *et al*., 2002) and in most of the cases wheat varieties were replaced with new varieties due to susceptibility of the rusts Rodf *et al*. (1992); Haq *et al*. (2002);Hussain *et al. (*2010).

Before green revolution, upto 1965, tall statured wheat cultivars were grown in Pakistan. In mid 60s, semi dwarf germplasm which was highly responsive to fertilizer, was introduced, resulting in the release of Mexipak 65, Lylpur 73, Pari 73, and Bluesilver. In early 80s, Pak-81 covered most of the area of wheat in Pakistan. All of these varieties were banned/replaced by the wheat growers because of their high susceptibility to Brown and Yellow rust. At the moment Inqilab-91 is major variety covering more than 50% area of the Barani tract.

In Pakistan, the focus is on improving bread wheat germplasm and development of cultivars that can combat drought stress and possess high yield potential with improved quality traits especially chapatti quality and disease resistance. Thus, wheat cultivar Chakwal-50 (Registration No. 2KC050) was developed which exhibited desirable features (erect, narrow leaves with strong wax) coupled with high tiller production. The commercial release of this variety has significantly contributed to overall wheat production in the country. In the present study, its unique features are discussed.

MATERIALS AND METHODS

Chakwal-50 is a selection from a cross made at CIMMYT Mexico among the wheat genotypes possessing characters suitable for rainfed areas having parentage, ATTILA /3/ HUI/CARC// CHEN/CHTO/4/ ATTILA. In 1999 -2000 this entry was evaluated at Barani Agricultural Research Institute, Chakwal under 20th Elite Spring Wheat Yield Trial 1999. The entry exhibited variants, so 50 plants possessing desirable features were selected and their seed was multiplied for yield evaluation against local check varieties.

In 1999-2000 yield potential and other morphological traits of Chakwal-50 were compared with commercial variety Chakwal-97 at Barani Agricultural Research Institute Chakwal. In the following season (2000-2001) Chakwal-50 was again tested for yield performance against Rawal-87, Chakwal-97, and

Kohistan-97 at Barani Agricultural Research Institute, Chakwal. A triplicated randomized complete block design (size of each plot was 9 m^2) was used for all trials. Standard agronomic practices were applied from sowing to harvesting. At maturity, four central rows of each plot were harvested and thrashed with thresher to get the grain yield. Similarly Micro Trials at eight diverse locations of the Punjab province were sown in 2001-02. Standard agronomic practices were followed from sowing to harvesting at all locations. Data of various morphological traits such as days taken to heading, plant height (cm), spike length (cm), grains per spike, 1000-grain weight (g), days taken to maturity and yield (kg/ha) were recorded. Plant height, grains per spike, spike length and 1000-grain weight were recorded by calculating average of 10 plants selected in each plot.

Chakwal-50 was also tested at 18 and 16 diverse locations of Pakistan in the National Uniform Wheat Yield Trial (NUWYT) in 2002-03 and 2003-04, respectively, conducted by the National Coordinator (Wheat), National Agricultural Research Centre, Islamabad. Each of these field trials was arranged in an RCBD with 4 replications. The size of the plots in each replication was 9 m^2 (5 × 1.8 m). Standard agronomic practices were followed.

Analysis of variance was performed on each measured trait using appropriate procedure of the MSTAT-C computer software package. Differences among means were tested by the least significant difference test at the 5% probability level.

For yellow rust (*Puccinia striiformis*) and brown rust (*Puccinia recondita)*, pathological studies were conducted at 8 location of Pakistan in National Wheat Disease Screening Nursery (NWDSN) during 2005-06 and 2006-07 by Crop Diseases Research Institute, Islamabad.

The Coefficient of Infection (CI) for both rusts was calculated following the procedure used in CIMMYT and USDA Loegering (1959). The reaction and response values of various disease reactions are given below

Reactions and their response values for wheat rusts

Reaction	Response	Response value
No Disease	0	0.0
Resistant	R	0.2
Resistant to moderately resistant.	R-MR	0.3
Moderately Resistant	MR	0.4
Moderately resistant to moderately susceptible.	MR-MS	0.6
Moderately susceptible	MS	0.8
Moderately susceptible to susceptible	MS-S	0.9
Susceptible	S	1.0

Coefficient of Infection was calculated by multiplying the response value with the intensity of infection in percent. Average Coefficient of Infection (ACI) was derived from the sum of CI values of each entry divided by the number of locations.

After some modifications, a rating scale for disease resistance was adopted by PARC in 1982 for use with cereal rusts (Aslam, M.1982), based on scale by Doling (1965)**,** for selection of wheat varieties resistant to powdery mildew and later adopted by ARC of Great Britain for the farmers.

The highest ACI of a candidate line is set at 100 and all other lines are adjusted accordingly. This gives a relative percentage attack (RPA) for each test entry. The average RPA is then calculated for each entry and is known as country averaged relative percentage attack (CARPA). This CARPA is then converted into an index number between 0-9, where 0 denotes the most susceptible and 9 the highly resistant.

The RRI was calculated according to the following formula.

$$RRI = \frac{(100 - CARPA) \times 9^{*}}{100}$$

- The maximum index number of CARPA

Example for the calculation of RRI of rust reaction

Variety	Reaction			CI total	ACI	CARPA	RRI
	Location 1	Location 2	Location 3				
A	30S	10MRMS	5S				
CI	30.0	6.0	5.0	41.0	13.7	100	0
B	TR	30MRMS	10MR				
CI	0.2	18.0	4.0	22.2	7.4	54	4
C	5MSS	10RMR	5MR				
CI	4.5	3.0	2.0	9.5	3.2	23.3	7

The desirable index and acceptable Index number for rusts are:

Disease	Desirable Index	Acceptable Index
Yellow rust	7 and above	5
Leaf rust	7 and above	5

CI%* = Coefficient of Infection

Karnal bunt (*Neovossia indica)* studies were conducted by Plant Pathology Division, Barani Agricultural Research Institute, Chakwal. For this purpose seed samples from four districts of Punjab from where disease incidence was reported, were collected and coefficient of infection for Karnal bunt was calculated.

To find out the optimum sowing time and seed rate, trials were conducted at Barani Agricultural Research Institute, Chakwal where Chakwal-50 was sown on five different sowing dates starting from 1st October to 1st December with an interval of 15 days and for optimum seed rate, four seed rates ranging from 100 to 175 kg/hectare were used for consecutive two years (2002-03 and 2003-2004).

Example for the calculation of Coefficient of infection of Karnal Bunt by Aujla *et al*., (1989)

Grade of infection	Healthy gains	Spores at germinal tip	Blacking up to groove	3/4 grain bunted	whole grain bunted
Numerical value	0	0.25	0.5	0.75	1
*No. of grains	200	75	50	25	10
Values after multiplication.	0 x 200= 0	0.25 x 75=18.75	0.5 x 50=25	0.75 x 25=18.75	1 x 10=10

*Total grains with different grades of disease infection in a sample: 200+75+50+25+10=360

Total value after multiplying with Numerical values 0+18.75+25+18.75+10 = 72.50

$$\text{Coefficient of infection} = \frac{\text{Total value after multiplying with Numerical values}}{\text{Total grains}} \times 100$$

$$\text{Coefficient of infection} = \frac{72.50 \times 100}{360} = 20.14$$

Coefficient of infection (Range)	Category
0	Highly resistant (1R)
0.1 - 5	Resistant (2R)
5.1 - 10	Moderately susceptible (1S)
10.1 – 20	Susceptible (2S)
20.1 and above	Highly Susceptible (3S)

To determine the fertilizer requirements of Chakwal-50, trials were conducted at Barani Agricultural Research Institute, Chakwal 2002-03 and 2003-04. In these trials 10 different combinations of Nitrogen, Phosphorous and Potash were applied at the time of sowing under rainfed conditions.

Quality assessments included grain ash, grain protein, gluten consistency, wet gluten, dry gluten content, chapati quality and test weight were carried out in the Cereal Laboratory of National Agricultural Research Centre, Islamabad for consecutive two years (2002-03 and 2003-2004).

RESULTS AND DISCUSSION

Chakwal-50 was tested in replicated varietal trials conducted at Barani Agricultural Research Institute, Chakwal for two consecutive years (1999-2000 and 2000-2001). In 1999-2000 the mean yield of Chakwal-50 was 4067 kg ha^{-1} compared with 3156 kg ha^{-1} for Chakwal-97 (Table 1). In 2000-2001 (Table 2) the grain yield of Chakwal-50 was 833 kg ha^{-1} compared with 667 kg ha^{-1} (Rawal-87), 639 kg ha^{-1} (Chakwal-97) and 611 kg ha^{-1} (Kohistan-97).

In micro wheat yield trial in 2001-02, Chakwal-50 was tested at 7 different sites of the Punjab. The grain yield of Chakwal-50 was 3.9, 5.7 and 7.6 % more than the standard cultivars Rawal-87, Inqilab-91 and Chakwal-97, respectively (Table 3).

Chakwal-50 was also tested in NUWYT (RF) for two wheat-growing seasons (2002-03 and 2003-04). In 2002-03 Chakwal-50 out yielded the local check variety by 10.5% (Table 4). Similarly, during wheat-growing season 2003-04, the grain yield of Chakwal-50 was 10.1% higher than the local check variety (Table 5).

As for as reaction of yellow and brown rust is concerned, it was observed that reading of Relative Resistance Index fell in the acceptable limit i.e., 5 or above (Table 6 & 7).

For Karnal bunt reaction, it was observed that range of Coefficient of Infection of all the samples of Chakwal-50 was 0.02 – 1.76, which showed the resistance against Karnal bunt (Table 8).

According to the results of sowing date and seed rate trials the best planting time for Chakwal-50 was 15th October to 15th November (Table 9) while best seed rate was 125 kg ha^{-1} (Table 10).

After conducting fertilizer trial, it was observed that Chakwal-50 gave best yield when Nitrogen, Phosphorous and Potash were applied @ 90:60:30 kg ha^{-1}, respectively (Table 12).

Two years data of quality characteristics including 1000-grain weight, Grain Ash, Grain Protein, Gluten Consistency, Wet Gluten, Dry Gluten Content, Chapati Quality and Test Weight were assessed (Table 13) . All the quality characters were acceptable according to the standard of quality of Pakistan.

Table 1. Yield performance of Chakwal-50 in Preliminary Wheat Yield Trial during 1999-2000.

Lines/Varieties			Seed Yield (kg ha^{-1})	% increase over Chakwal-97
Chakwal-50			4067	22.4
Chakwal-97			3156	
LSD (0.05)	208.0	CV %	11.2	

Table 2. Yield performance of Chakwal-50 in Regular Wheat Yield Trial 2000-2001.

Lines/Varieties		Seed Yield (kg ha^{-1})	Increase (%) Over Check Varieties		
			Rawal-87	Chakwal-97	Kohistan-97
Chakwal-50		833	19.9	23.3	26.6
Rawal-87		667			
Chakwal-97		639			
Kohistan-97		611			
LSD (0.05)	104.3	CV %	10.9		

Table 3. Chakwal-50 in Micro Wheat Yield Trial (Rainfed) 2001-02

Locations	Varieties & Yield (kg ha^{-1})			
	Chakwal-50	Rawal-87	Inqilab-91	Chakwal-97
Chakwal	2639	2806	2383	3361
Piplan	3850	3783	3528	3956
Kot nainan	3567	3433	3200	2500
Gujrat	1739	1689	1767	1706
Fateh jang	1917	1928	1819	1847
Attock	1000	1133	1050	1133
Islamabad	3133	2367	3067	1967
Average	2549	2448	2402	2353
% increase over check		3.96	5.76	7.6
LSD (0.05)	543	480	740	540
CV %	9.3	13.4	11.4	9.7

Table 4 .Average yield of Chakwal-50 in National Uniform Wheat Yield Trial (Rainfed) during 2002-03

Line /Variety	Provinces and yield (kg ha^{-1})			
	Punjab 10- Sites (Average)	NWFP 6 – Sites (Average)	AJK 2 – Sites (Average)	Pakistan 18 -Sites (Average)
Chakwal-50	3561	3053	1568	3170
NR – 206	3063	2761	1889	2832
Faisalabad – 1	3310	2772	1764	2959
BARS –1	3058	2700	1675	2785
SN –7	2977	2625	1783	2727
V –6	2960	2491	1778	2673
98C017	2994	2513	1456	2663
DN –18	3061	2867	2073	2887
NRL –9912	3081	2640	1624	2772
NR –192	3043	2773	1694	2803
PR –77	3107	2869	1491	2448
V –00146	3235	2989	1595	2971
KT –2000	3189	2841	1594	2896
97B2333	3096	2677	1795	2812
MAW –1	2926	2873	1474	2747
Local Check	3186	2623	1457	2806
LSD (0.05)	156	195	356	115
CV %	11.4	12.5	21.5	12.4

Table 5. Average yield performance of Chakwal-50 in National Uniform Wheat Yield Trial (Rainfed) 2003-04

Line /Variety	Provinces and yield (kg ha^{-1})		
	Punjab 8- Sites (Average)	NWFP 8 – Sites (Average)	Pakistan 16 – Sites (Average)
BARS-3	3637	2908	3273
2KC033	3672	3223	3448
PR-80	3894	3352	3623
NR-234	4249	3535	3892
NRL-9912	3489	3101	3295
V-00055	4146	3265	3705
NR-231	3765	3422	3593
Chakwal-50	4165	3542	3853
KT-2000	3779	3286	3533
Local Check	3744	3183	3463
LSD (0.05)	186	260	159
CV %	9.8	16	12.8

Table 6.Reaction of Chakwal-50 to Yellow Rust and RRI during 2005-06 and 2006-07

Year	Locations			
	CCRI, Pirsabak	NIFA, Peshawar	NARC, Islamabad	RRI
2005-06	5MSS	30 MSS	5 S	8
2006-07	5S	5MR	5S	8.3

Table 7.Response of Chakwal-50 to Brown Rust during 2005-06 and 2006-07

Year	Locations					
	RARI, Bahawalpur	AARI, Faisalabad	CDRI Karachi	NIA, T.Jam	WRI, Sakrand	RRI
2005-06	5MRMS	0	20MS	30 MS	10 S	7
2006-07	5MS	0	0	0	0	8.6

Table 8. Response of Chakwal-50 to Karnal Bunt

Locations	Chakwal-50	CI %
Chakwal	Resistant	0.24
Multan	Resistant	0.02
Layyah	Resistant	1.76
Faisalabad	Resistant	0.46

Table 9. Effect of sowing date on the grain yield of Chakwal-50

Sowing date	Yield (kg ha^{1})		
	2002-03	2003-04	MEAN
Ist Oct.	2402	2503	2452
15th Oct.	3217	4977	4097
Ist Nov.	3311	5348	4329
15th Nov.	2815	4352	3583
Ist Dec.	2105	2841	2473

Table 10. Effect of seed rate on the grain yield of Chakwal-50

Seed rate	Yield (kg ha^{1})		
	2002-03	2003-04	MEAN
100 kg/ha	2432	3232	2832
125 kg/ha	3515	4240	3877
150 kg/ha	2951	4150	3550
175 kg/ha	3290	4090	3690

Table 11. Data of different traits of Chakwal-50

Days taken to heading	Plant height(cm)	Spike length (cm)	Grains/spike	1000-grain weight(gm)	Days taken to maturity
128	99	14	62	38.41	175

Table 12.Effect of fertilizer on the grain yield of Chakwal-50

Nutrients (kg/ha)			Yield (kg ha^{-1})		
N	P	K	2002-03	2003-04	MEAN
0	0	0	1717	1378	1548
0	60	30	2150	1705	1928
30	60	30	2756	1914	2335
60	60	30	3279	2032	2656
90	60	30	3962	3267	3615
120	60	30	3723	3062	3393
60	0	30	2350	3291	2821
60	30	30	2673	3193	2933
60	90	30	3451	2364	2908
60	60	0	2439	2734	2587
60	60	60	2978	3288	3133

Table 13.Quality characteristics of advance wheat line Chakwal-50

Quality Traits	2002-2003	2003-04
1000- grain weight (g)	38.41	38.48
Grain Ash (%)	1.51	1.56
Grain Protein dry based %(d.b)	12.70	12.01
Gluten Consistency	Medium Strong –Strong(MS-S)	Strong to Medium Strong (S-MS)
Wet Gluten %	26.51	16.53
Dry Gluten Content (%)	8.07	6.47
Chapati Quality	V.good	V.good
Test Weight(kg/hector liter)	75.8	75.8

Table 14.Rainfall data (mm) recorded at Barani Agricultural Research Institute, Chakwal

Year	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Total
1999-2000	9.3	18.0	0	61.5	73.0	10.0	11.0	182.8
2000-2001	0	0	8.5	0	0	52.5	38.0	99.0
2001-2002	45.7	3.5	0	0	49.0	33.0	13.0	144.2
2002-2003	17.1	0.5	17.0	10.0	145.0	49.7	27.1	266.4
2003-2004	35.6	13.2	13.4	65.1	17.2	9.2	62.3	216.0
004-2005	34.3	2.4	30.4	77.4	63.0	75.3	10.1	292.9
2005-2006	14.0	3.4	0	14.3	23.9	55.2	8.4	119.2
2006-2007	0	42.2	30.2	0	166.0	147.0	7.8	393.2

Conclusion: Chakwal 50 is not only a high-yielding variety possessing multiple disease resistance and better quality traits. Due to its better adaptability, in rainfed region it has the potential to be replaced with the previously approved varieties.

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