INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
12–854/2013/15–4–701–706
http://www.fspublishers.org

Full Length Article

Dharabi-11: A New High Yielding Drought and Disease Tolerant Wheat Variety

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Abstract

Dharabi-11 is a high yielding, disease and drought tolerant spring wheat variety evolved at Barani Agricultural Research Institute (BARI), Chakwal and released for general cultivation in 2011 for rainfed areas. The variety was originated from the cross HXL7573/2*BAU//PASTOR having pedigree CMSS97Y03676S-040Y-050M-040SY-030M-21SY-010M-0Y-OSY. Selection cycles resulted in genetic purity and uniformity of said line and was evaluated in multiple trials conducted at BARI, Chakwal and other ecological zones of the country from 2005-2006 to 2010-2011 for desirable economic traits like high grain yield, good chapatti/bread making quality, drought and disease tolerance. On an average "Dharabi-11" exhibited 9.1% higher grain yield compared to other commercial varieties, showed desirable resistance against stem rust (local race as well as Ug 99), yellow rust, leaf rust and Karnal bunt and has longer roots (61 cm) enabling the plant to tolerate drought stress. The grain size is medium (42.47g 1000 grain weight) with 12.17% protein and has very good chapatti/bread making quality. This variety was approved for general cultivation in rain fed areas of Pakistan by the Punjab Seed Council in its 41st meeting held on 25th July, 2011 and is the best suited variety for rain fed areas of the country.

Keywords: Wheat variety; High yielding; Drought and disease tolerance; Rain fed areas

Introduction

Wheat (*Triticum aestivum* L.) is a staple diet of major population in Pakistan (Ahmad *et al*., 2007; Ajmal *et al*., 2009) and supplies 72% of the calories and proteins in the average diet (Azam *et al*., 2007). It contributes 13.1% to value added in agriculture and 2.7% to GDP of Pakistan (Anonymous, 2011). Out of total wheat production area of Pakistan, 12.3% is under rain fed conditions and contributes about 7% and 7.65% towards the total production of Punjab and Pakistan, respectively (Anonymous, 2009). The precipitation during the early Rabi season is generally very low and the crop remains under water stress conditions (Fig 1). There is considerable year to year variation in precipitation in the rain fed areas.

Both biotic and abiotic stresses are the major threat to crop production in Pakistan. Brown rust (*Puccinia recondita*) and yellow rust (*Puccinia striiformis*) are among the serious diseases of wheat and in most of the cases wheat varieties were replaced with new cultivars due to susceptibility of the rusts (Rattu *et al.*, 2007). Wheat varieties having narrow, erect to semi erect leaves with deep root system lead to higher biomass and grain production and are the most suitable for cultivation in rainfed areas. Presently, Chakwal-50, GA-2002 and Inqilab-91 are commonly grown in the rainfed areas of the Punjab. As these varieties have become susceptible to rusts therefore, it is very necessary to develop disease tolerant wheat varieties suitable for rainfed areas.

'Dharabi-11' a high yielding wheat variety tolerant to drought and disease has been approved for general cultivation in rainfed areas. The general cultivation of this variety will not only save the country from any upcoming threat of Ug 99 (a race of stem rust) but will also enhance wheat production in the country.

Materials and Methods

Dharabi-11 (registered as '6C016') was amongst the 23rd SAWSN – W (Semi-Arid Areas Wheat Screening Nursery-White) with entry No.127 received from National Coordinated Wheat Program NARC, during 2005. The parentage and pedigree of this line is HXL7573/2*BAU//PASTOR and CMSS97Y03676S-040Y-050M-040SY-030M-21SY-010M-0Y-0SY. The entry exhibited variants, so 20 plants possessing desirable features were selected and their seed was multiplied for yield evaluation against local check varieties.

The variety was subjected to different selection cycles in number of repeated trials i.e., preliminary evaluation, on-station wheat trials, multi locational trials and National Uniform Wheat Yield Trials. The breeding approach

To cite this paper: M. Tariq, A. Mahmood, M.A. Mian, N.M. Cheema, M. Sabar, M. Ihsan and A.U. Rehman, 2013. Dharabi-11: A new high yielding drought and disease tolerant wheat variety. *Int. J. Agric. Biol*., 15: 701–706

adapted for the development of said variety had already been used by many breeders (Ahmad *et al.*, 2010; Hussain *et al.*, 2010a; Rahman *et al.*, 2012).

In 2005-2006, yield potential and other morphological traits of 'Dharabi-11' were evaluated against commercial variety GA-2002. During 2006-2007, this variety was tested in preliminary wheat yield trial in randomized complete block design (RCBD) for its yield performance against Chakwal-97 and GA-2002 at BARI, Chakwal. Standard field management practices were applied for uniform healthy crop stand. During 2007-2008, it was evaluated in regular yield trial against Chakwal-97 and GA-2002. Its performance was evaluated in micro wheat yield trials at eight diverse locations of Punjab province during 2008-2009 under RCB design having three replications with two local checks Auqab-2000 and Chakwal-50. Standard agronomic practices were followed from sowing to harvesting at all locations. Data of various morphological traits such as days to heading, plant height, spike length, grains per spike, 1000-grain weight, days to maturity and yield were recorded. Plant height, grains per spike and 1000-grain weight was recorded by calculating average of 10 plants selected in each plot.

Dharabi-11 was also tested at multi locations in Pakistan under the National Uniform Wheat Yield Trial (NUWYT) in 2009-2010 and 2010-2011, conducted by the National Coordinated Wheat program, National Agricultural Research Centre, Islamabad. The NUWYT was planted in RCB design with four replications having plot size of 5 × 1.8 m. Standard agronomic practices were followed. Pathological studies were conducted at seven locations of Pakistan under National Wheat Disease Screening Nursery (NWDSN) during 2009-2010 and 2010-2011 by Crop Diseases Research Institute NARC, Islamabad. The Coefficient of Infection (CI) for both yellow rust (*Puccinia striiformis*) and leaf rust (*Puccinia recondita*) was calculated following the procedure in practice by CIMMYT and USDA. Disease infection types at adult stage were recorded according to 0-9 scale as described by McNeal *et al.* (1971).

Coefficient of Infection (CI) was calculated by multiplying the response value with the intensity of infection in percentage. Average Coefficient of Infection (ACI) was derived from the sum of CI values of each entry divided by the number of locations. The candidate line having the highest ACI was given 100 and other lines were rated accordingly to calculate the Country Average Relative Percentage Attack (CARPA). From CARPA, Relative Resistance Index (RRI) is calculated on a 0 to 9 scale, where '0' denotes most susceptible and '9' highly resistant.

The RRI was calculated according to the following formula:

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

Karnal bunt (*Neovossia indica)* studies were conducted by Plant Pathology Division at BARI, Chakwal. For this purpose, seed samples from 23 different locations of Punjab were collected and coefficient of infection for Karnal bunt was calculated according to the method described by Aujla *et al*. (1989).

Agronomic studies were carried out to find out the optimum sowing time, seed rate and fertilizer requirements. For optimum sowing time of the variety 'Dharabi-11', the trials were planted on five different sowing dates starting from 15th October to 1st December with an interval of 15 days. Four seed rates ranging from 100 to 175 kg ha^{-1} were studied for two consecutive years (2009-2010 and 2010-2011). In another trial, 10 different combinations of Nitrogen, Phosphorous and Potash were applied at the time of sowing under rainfed conditions with split plot design comprising three replications to determine the fertilizer requirements of the variety.

Grain weight, grain ash, grain protein, gluten consistency, wet and dry gluten contents, chapatti making quality and test weight were carried out by the Cereal Laboratory of National Agricultural Research Centre, Islamabad during the years 2009-2010 and 2010-2011. Root length, leaf size and its orientation along with wax on leaves were recorded at different plant stages to evaluate the response of the variety against drought.

Analysis of variance was performed on all measured traits using statistical tool MSTAT-C, whereas differences among means were tested by the least significant difference test at 0.05 probability level.

Results

On-station Wheat Trials

Preliminary and regular yield trials were conducted to assess the performance of the variety Dharabi-11 from 2005 to 2009. The variety gave 4332 kg ha^{-1}grain yield as compared to the check variety GA-2003 (3932 kg ha^{-1}) during initial evaluation in 2005-2006 of 23rd SAWSN-W (Semi-Arid Areas Wheat Screening Nursery-White). Whereas in preliminary yield trial, the variety yielded grains 4841 kg ha^{-1}against the check varieties Chakwal-97 (4542 kg ha^{-1}) and GA-2002 (4356 kg ha^{-1}) during the year 2006-2007. In regular yield trial, the grain yield of Dharabi-11 was 5567 kg ha^{-1}, whereas the two checks GA-2002 and Chakwal-97 yielded 4356 and 4311 kg ha^{-1} respectively (Fig. 2).

Multi-locational Trials (Micro Wheat Yield Trials)

Dharabi-11 was evaluated at eight locations in Punjab under micro yield trials (2008-2009). The average yield of all 8 sites was 2930 kg ha^{-1} as compared to the average yield of 2 local checks Auqab-2000 (2827 kg ha^{-1}) and Chakwal-50 (2812 kg ha^{-1}). The increase in grain yield over checks Auqab-2000 and Chakwal-50 was recorded as 3.64% and 4.19%, respectively (Table 1).

Table 1: Performance (Average grain yield) of Dharabi-11 in micro wheat yield trial (rainfed) 2008-2009

Sr. No.	Varieties	Average Grain Yield (kg ha-1)	% Increase over Check	
			Auqab2000	Chakwal-50
1-	Dharabi-11	2930	3.64	4.19
2-	Auqab-2000	2827		
3-	Chakwal-50	2812		

Table 2: Performance (Average Yield) of Dharabi-11 (kg ha^{-1}) in National Uniform Wheat Yield Trial (Rainfed) 2009-2010

Line/Entry	Balochistan (2 sites)	Punjab (5 Sites)	KPK (7 Sites)	Pakistan (12 Sites) Excluding 2 sites of Balochistan
Dharabi-11	482	3692	3003	3290
L. Check	539	3575	2669	3047
Grand Mean	547	3430	2981	3168
C.V. (%)	22.6	8.6	20.0	15.6
LSD (0.05)				
Location	**	173	432	339
Variety	N.S	184	314	198
L × V	N.S	411	829	**

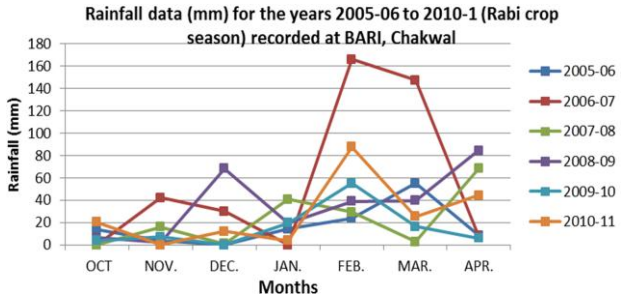

Fig 1: Precipitation recorded at Barani Agricultural Research Institute, Chakwal

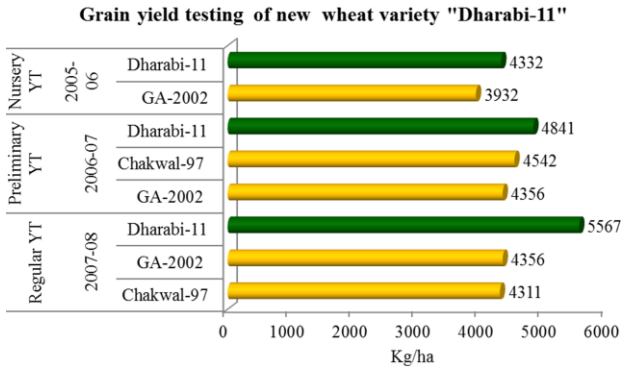

Fig 2: Performance of Dharabi-11, in on-station yield trials

National Uniform Wheat Yield Trials

Highly significant differences were found among the test entries for their grain yield performance at each location. The grain yield of the variety was 5813, 4161, 3161, 3894 and 1432 kg ha^{-1} at Bahawalpur, Mianwali, Chakwal, Islamabad and Attock, respectively in Punjab. The said line remained at the top with an average grain yield of 3692 kg ha^{-1} amongst 11 wheat lines. The results of NUWYT 2009-2010 also revealed that this variety gave an average grain yield of 3290 kg ha^{-1}, while check variety produced 3047 kg ha^{-1} at country level with a yield advantage of 7.9% than the local check (Table 2).

The summary of yield performance of 'Dharabi-11' tested at different locations has shown an increase in grain yield of 5.4%, 14.8%, 4.2%, 3.6% and 17.6% over local checks and commercial varieties GA-2002, Chakwal-50, Auqab-2000 and Chakwal-97, respectively (Table 3).

Agronomic Studies

The agronomic trials were conducted at BARI, Chakwal to determine best suiting sowing dates, seed rates and fertilizer requirements for Dharabi-11 under rain fed conditions during 2009-2010 and 2010-2011. The data in Table 4 revealed that the variety 'Dharabi-11'gave higher yield when sown on 1stof November followed by plantation done on 15th of November. The results of seed rates trials showed that the maximum yield of 1689 kg $ha^{-1}$of 'Dharabi-11' was obtained with seed rate of 125 kg ha^{-1} (Table 5). Different doses of fertilizer were applied at the time of sowing. Table 6 indicates that the best yield of 2073 kg ha^{-1} was obtained with the application of NPK fertilizer @ 90:60:30 kg ha^{-1}at sowing time.

Biotic Stress Studies

The response of the variety 'Dharabi-11'towards yellow and leaf rust diseases was recorded in the trials conducted at BARI and other locations of the country during 2009-2010. In yellow and leaf rusts screening, the score for the terminal reaction (TR) of Dharabi-11 was 0, 5S and 0 at Pirsabak, Peshawar and Islamabad, respectively. Average coefficient of infection (ACI), country average relative percentage attack (CARPA) and relative resistance index (RRI) were 1.7, 2.5 and 8.8, respectively (Table 7, 8). During the year 2010, the variety was also tested in Wheat Stem Rust (Ug 99) Screening Nursery at Kenya. The reaction against the stem rust disease race Ug 99 was 10MS-S.

The response to aphid attack was recorded at Faisalabad and Bahawalpur and it was 11.13 and 8.68 aphids/tiller, respectively. If a variety have less than 15 aphid/tiller, it is acceptable.

Quality Assessment Studies

Quality studies showed that grains of Dharabi-11 are medium bold (42.47 g/1000 grain) with high gluten contents (17.21% of wet gluten contents and 7.41% of dry gluten contents). Moreover, the grain has high protein contents (12.17%) and possesses very good chapatti making quality (Table 9).

Table 3: Performance (Mean yield) of Dharabi-11 as compared with other recommended varieties in on-station and multi-location yield trials

Year	Name of Trial	No. of Trials	Mean grain yield (kg ha^{-1})					
			Dharabi-11	GA-2002	Local Check*	Chakwal-50	Auqab-2000	Chakwal-97
2005-2006	SAWSN	1	4332	3932	-	-	-	-
2006-2007	Preliminary	1	4841	4541	-	-	-	4542
2007-2008	Regular	1	5567	4356	-	-	-	4311
2008-2009	Micro	8	2930	-	-	2812	2827	-
2009-2010	NUWYT(Punjab)	5	3692	-	3575	-	-	-
2010-2011	NUWYT(Pakistan)	15	3290	-	3047	-	-	-
Average % increase over check varieties				14.8%	5.4 %	4.2 %	3.6%	17.6 %
Overall % increase						9.1%		

*Different local checks at different locations

Table 4: Average seed yield (kg ha^{-1}) as affected various sowing dates (2009-2011)

Varieties	Sowing Dates				
	15th Oct.	1st Nov.	15th Nov.	1st Dec.	15th Dec.
Dharabi-11	828	1354	900	510	397
Chakwal-50	678	1228	1042	711	534

LSD (0.05) for: Sowing Dates = 329, Varieties = 197, S.D. x Var. = 442, CV (%) = 31.8

Table 5: Average seed yield (kg ha^{-1}) as affected by different seed rates, 2009-2010

Varieties	Seed rates (kg ha^{-1})			
	100	125	150	175
Dharabi-11	1532	1689	1642	1695
Chakwal-50	1108	1298	1698	1698

Table 6: Effect of fertilizer on the grain yield of Dharabi-11 during 2009-2010

S. No.	Treatment (kg ha^{-1})			Grain Yield (kg ha^{-1})
	N	P	K	
1	0	0	0	1407
2	0	60	30	1709
3	30	60	30	1809
4	60	60	30	1828
5	90	60	30	2073
6	120	60	30	1983
7	60	0	30	1967
8	60	30	30	1890
9	60	90	30	1922
10	60	60	0	1922
11	60	60	60	2002

LSD (0.05) for: Fertilizer = 945, CV (%) = 25

Drought Adaptive Traits

Dharabi-11 has long roots up to 61 cm as compared to Inqilab-91 having 48 cm (Fig. 3). Dharabi-11 has narrow, erect and rolling leaves with strong wax and all these traits are associated with drought tolerance.

Discussion

The main focus in the development of new wheat variety was higher yield, tolerance against drought and diseases.

Table 7: Response of Dharabi-11 to yellow rust along with Terminal Reaction (TR), Average Coefficient of Infection (ACI), Country Average Relative Percentage Attack (CARPA), Relative Resistance Index (RRI) during 2009-2010

Genotype	CCRI Pirsbak	NIFA Peshawar	NARC Islamabad	ACI	CARPA	RRI
Dharabi-11	0	5 S	0	1.7	2.5	8.8
Morocco (Susceptible check)	80 S	80 S	90 S	-	-	-

S= Susceptible
Source: Rust report of Crop disease Research Programme, NARC, Islamabad 2009

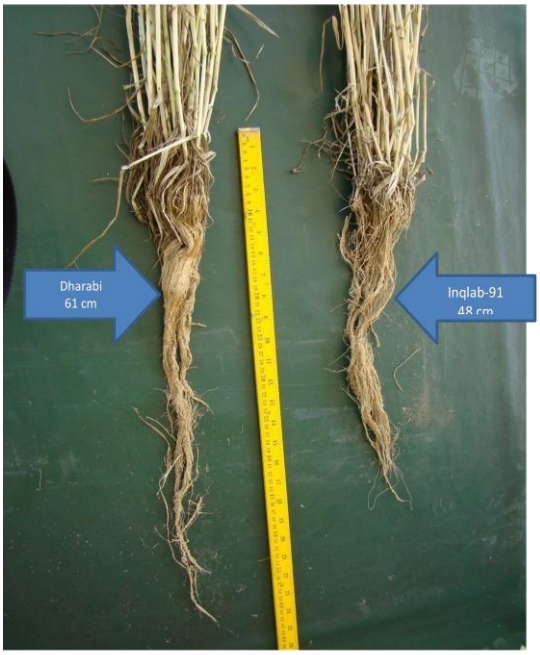

Fig 3: Comparison of root length for Dharabi-11

Dharabi-11 gave a yield advantage of 6.6% to 29% over check varieties in station trials. The genotype-environment interaction for grain yield was higher in micro trials

Table 8: Response of Dharabi-11 to leaf rust along with Terminal Reaction (T.R), Average Coefficient of Infection (ACI) during 2009-2010

Genotype	RARI Bahawalpur	AARI Faisalabad	CDRI Karachi	NIA T. Jam	WRI Skrand	F.F. Thatta	F.F Kunri	ACI
Dharabi-11	0	0	TS	0	0	TMS	TMS	0.37
Morocco (Susceptible check)	20 S	20 S	TS	0	0	TS	0	-

S = Susceptible
MS = Moderately Susceptible
TMS = Traces Moderately Susceptible
Source: Rust report of Crop disease Research Programme, NARC, Islamabad 2009-2010

Table 9: Quality characteristics of new wheat variety Dharabi-11

Quality traits	Results
1000-G. Wt. (g)	42.47
Grain color	Amber
Grain Ash (%)	1.15
Grain Protein (%d.b)	12.17
Gluten Consistency	MS-S*
Wet Gluten %	17.21
Dry Gluten Content (%)	7.41
Chapati Quality	V. Good
Test Weight(kg/hl)	75.63

*MS-S = Medium strong - strong

indicating that different soil types and temperatures are also important parameters for estimating the crop yield. Dharabi-11 performed better than the checks on average basis across the locations. Highly significant differences were observed among the test entries for grain yield at each location indicating the genotypic differences of the wheat lines in NUWYT. Dharabi-11 performed much better at five locations under NUWYT, which is the major target area of rainfed tract. In addition, the variety remained at the top amongst 11 test lines.

The rainfall data showed highly variable distribution pattern during the years of testing of the variety. The relative performance of Dharabi-11 remained stable in different years indicating the good yield potential under stress conditions.

Adequate soil moisture and favorable weather conditions at sowing time are important for increased crop yield (Anonymous, 2009). Under rainfed conditions, the sowing date depends on rainfall pattern i.e., frequency, duration and amount as well as the maturity period of a particular wheat variety (Tanner *et al.*, 1991). Mid-October to mid-November is the optimum time of sowing for most of the wheat varieties released for general cultivation in rain fed areas.

It was inferred from the trials conducted at BARI, Chakwal that by using seed rate of 125 kg ha^{-1}, highest grain yield (1689 kg ha^{-1}) of 'Dharabi-11' was obtained. These findings are in promise with those of Wright *et al.* (1982) and Guitard *et al.* (1961) who found that seeding rate of 100 kg ha^{-1} gave higher yields than lower rates.

The best yield (2073 kg ha^{-1}) of the variety was obtained when NPK fertilizer was applied @ 90:60:30 kg $ha^{-1.}$ These results are in conformity with the findings of Hussain *et al.* (2010b). Positive effects of increased fertilizer doses on wheat yield have also been reported by Sameen *et al.* (2002).

Rust diseases of wheat not only reduce the yield but also deteriorate the grain quality. Earlier released varieties have showed good yield potential but became susceptible to diseases which caused serious yield losses (Anonymous, 2005; Hussain *et al.*, 2010b). During the year 2010, Dharabi-11 was also tested in Wheat Stem Rust (Ug99) Screening Nursery at Kenya. The reaction against the stem rust disease race Ug99 was 10MS-S, which is in acceptable tolerant range. Dharabi-11 also showed resistance against yellow rust, leaf rust and Karnal bunt.

Seed quality is an important parameter that determines market acceptability of a commodity among the consumers. The grains of Dharabi-11 are medium bold with high gluten contents. These results are in accordance with those of Mustafa *et al.* (2010). The same results regarding quality characters have also been reported by Hussain *et al*. (2010c).

Longer roots (61 cm) of the variety enable the plant to tolerate drought more effectively as compared to Inqilab-91 (48 cm). As one might expect, root characteristics, such as depth and abundance, are known to be associated with performance under drought in many studies with wheat (Blum, 1988). Long roots enable the plants to extract water from the deeper soil layer and to maintain its turgor for a longer period. A thick wax layer reflect excess light rays away from the leaf thus preventing leaf heating without requiring transpiration. Narrow, erect and rolling leaves with strong wax are the other traits that contribute in drought tolerance ability (Richards, 1996).

In conclusion, "Dharabi-11" is a high yielding, disease and drought tolerant rainfed wheat variety and also possesses very good chapatti/bread making quality. Due to its better adaptability and good yield performance at different location all over the country, it has the potential to be replaced with the previously approved varieties, which are becoming more susceptible for diseases. The plant features have shown the waxy and erect nature of its leaves thus enabling it to withstand in water stressed environments.

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(Received 11 September 2012; Accepted 15 February 2013)