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DILKASH-20: A NEWLY APPROVED WHEAT VARIETY RECOMMENDED FOR PUNJAB, PAKISTAN, WITH SUPREME YIELDING POTENTIAL AND DISEASE RESISTANCE

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SUMMARY

Wheat Research Institute (WRI), Faisalabad, Pakistan, a premier foundational birthplace of the Green revolution in Pakistan, has played a vital role in attaining food self-sufficiency. Latest grown varieties have succumbed to ever-changing pathogens, unable to stand in the fields. Hence, the initiative to develop an indigenous type to withstand high disease pressure producing better grain yield transpired during 2008–2009, with the hybridization of Dilkash-20 (WBLL*2/4/SNI/TRAP#1/3/KAUZ*2/TRAP//KAUZ/5/ PB.96//LU26/HD2179). It proceeded with segregating generations from F2 to F7 from 2009 to 2016. During 2016–2017 and 2017–2018, its testing followed at station yield trials, including Preliminary (A) and Regular (B), under code V-16005. It produced a significantly higher yield (10.86% and 10.40%) than the check varieties (Faisalabad-08 [FSD-08] and Punjab-11 [PB-11]). In provincial trials, it out-yielded a check variety by 4.06%. Testing in national yield trials, line V-16005 produced 17.40% and 12.03% higher grain yield than check cultivars during 2018–2019 and 2019–2020, respectively. It yielded better when planted on the first 10 days of November with a 100 kg ha^{-1} seed rate and 120:90:60 NPK (kg ha^{-1}) fertilizer rate. The Dilkash-20 variety is a medium-height (105–115 cm), semi-erect producing 425 tillers per m^2, with 119 days to heading and 145–150 days to maturity. It is of excellent quality, with protein (15.1%), starch (52.7%), gluten (28.7%), and test weight (72.1 kg hl^{-1}), highly suitable for chapatti making. It has an effectual, durable resistance against brown and yellow rusts based on adult plant resistance genes. Therefore, the Punjab Seed Council approved Dilkash-20 for general cultivation throughout the irrigated areas of Punjab.

Keywords: Wheat variety, better yielding, rust resistant, enhanced quality, Punjab

Key findings: Dilkash-20 is a novel wheat genotype with higher yield potential and disease resistance, having better quality attributes and has approval for commercial cultivation in the irrigated areas of Punjab, Pakistan.

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INTRODUCTION

Wheat is an important staple food consumed by 2.5 billion people in more than 89 countries worldwide. Increasing global wheat demand will require 60% more wheat by 2050, as predicted by different prediction models (You *et al.,* 2014). Bread alone contributes about a fifth of the average daily intake of the human diet (Shewry and Hey, 2015). The population of Pakistan is growing at a considerable pace of 1.92% annually; thus, more attention should center on food production in all agricultural sectors (MoF, 2016). During 2021–2022, the area under cultivation for wheat decreased by 2.1% to 8.976 million ha. In 2020–2021, the area was 9.168 million ha. The production also declined by 3.9% to 26.394 million tonnes against 27.464 million tonnes a year before (Anon., 2022). Farmers need better varieties and production technology for improved livelihood supplied by plant breeders (Lantican *et al.,* 2016; Sarfraz *et al*., 2016). These newly developed varieties increase the pace of adoption as these adjust for biotic and abiotic stresses across multiple environments (Witcombe *et al.,* 2016; Shaukat *et al*., 2021).

Like other cereals, wheat also responds to fluctuating climatic conditions. According to a study, a yield reduction of about 6% happens if the mean minimum temperature increases by 1% at the reproductive stages of the crop life cycle (Asseng *et al.,* 2014; Putri *et al*., 2020). Combining inexpensive, diverse traits into a single genotype with stability across locations can produce the desirable varieties. The economic impact of the genotypes to yield stability across environments ranging from favorable to challenging conditions is the desired result of a breeding program (Fischer and Edmeades, 2010; Keating *et al.,* 2010; Chapman *et al.,* 2012).

All the necessary steps for variety development, including parent selection, hybridization, filial generation selection, advancement, yield stability testing in multiple environments, and quality materialized at WRI, Faisalabad. Disease resistance evaluation ensued with the collaboration of the Crop Disease Research Institute (CDRI), Islamabad. This research article details all the aspects of Dilkash-20. The Punjab Seed Council, Lahore, approved the said variety in 2021 for general cultivation to stabilize food security and cope with diseases and threats to the wheat crop.

MATERIALS AND METHODS

Developing the genotype, having parentage of WBLL*2/4/SNI/TRAP#1/3/KAUZ*2/TRAP//KAUZ /5/PB.96//LU26/HD2179 and pedigree as PB.35237-0A-0A-5A-0A-0A happened at the Wheat Research Institute (WRI), Faisalabad, Pakistan, through the selected bulk breeding method. The initiative to develop an indigenous variety that could withstand the high disease pressure and produce better grain yield than the already established varieties proceeded during 2008–2009 when the hybridization of Dilkash-20 started. From 2009 to 2016, it has undergone generation segregation from F_2 to F_7. During 2016–2017, it was tested in A-Trial (preliminary yield trial) for yield evaluation as V-16005. The trial in triplicates was in a randomized complete block design (RCBD) with a plot size of 8.1 m^2 (six rows, 27 cm apart, and 5 m in length). It produced better grain yield than check varieties, with a re-checked in a regular wheat yield trial (B-Trial) during 2017–2018 at WRI, Faisalabad, Pakistan. In the same year, V-16005 had broad testing in Punjab Uniform Wheat Yield Trial (PUWYT) for assessing yield performance and stability over 23 wider locations throughout the Punjab province.

Upon better performance in the PUWYT trial, its further testing followed in the National Uniform Wheat Yield Trial (NUWYT) during 2018–2020 throughout Pakistan, as conducted and maintained by the National Wheat Coordinator, PARC, Islamabad, at about 20 locations under the Punjab province with Alpha lattice design in duplicate. For disease screening, CDRI, Islamabad, surveyed the NUWYT trials of V-16005 against local rusts during said years. The methodology for planting, rust inoculation, and recording of rust data followed the method according to NUWYT Report 1996–1997 (Hussain, 1997).

The agronomic performance of V-16005 in terms of proper seed rate, planting time, and fertilizer requirements gained examination in separate field experiments for two years from 2018 to 2020 at WRI, Faisalabad. Adopting RCBD in triplicate continued for the seed rates and sowing dates experiments, with the fertilizer trial planted in strip plot design under RCBD in triplicate. For quality testing, the cereal technology laboratory of WRI, Faisalabad, analyzed the grain samples of the station and out-station of

the NUWYT trials following the standard protocols developed by the American Association of Cereal Chemists (Anon., 2000) and the International Association for Cereal Science and Technology (Anon., 1994).

DNA Fingerprinting of Dilkash-20 ensued at the DNA fingerprinting lab at Agricultural Biotechnology Research Institute, AARI, Faisalabad, Pakistan. The objective of the DNA fingerprinting was to compare the genetic background of Dilkash-20 with already registered varieties to maintain genetic diversity among the registered varieties. Seeds of Dilkash-20 sown in a greenhouse in pots had a temperature of 28 °C. Following other standard agronomic practices, after seedling establishment till 4–5 leaves, DNA extraction on five seedlings previously obtained and stored at -40 °C proceeded. Genomic DNA isolation used the method described in previous studies (Iqbal *et al*., 2019; Iqbal *et al*., 2021b). DNA quantification and the quality check continued using a Nano-drop spectrophotometer (ND 2000). The prepared DNA dilution obtained 20 ng/µl concentration, which is required in PCR (Rahman *et al.,* 2022).

For a well-representative picture of the wheat genome, selecting 233 SSR markers (Iqbal *et al.,* 2021a) occurred evenly distributed throughout the A, B, and D genomes. The assembled PCR reaction for each SSR marker used a green PCR master mix following the standard procedure described in Jamil *et al.* (2020a). The cycling conditions were as follows: initial denaturation at 94 °C for 5 min, followed by 35 cycles of 94 °C for 1 min; annealing for 1 min at variable temperatures for each primer as described by Jamil *et al.* (2020b); polymerization at 72 °C for 1 min; finally, an elongation at 72 °C for 7 min. PCR assembly continued by Polyacrylamide Gel Electrophoresis (PAGE) for PCR products visualization and their scoring using the protocol described in Jamil *et al.* (2021b).

Statistical analysis

The binary data obtained after scoring underwent statistical analysis to estimate Polymorphic Information Content (PIC) to approximate the usefulness of different SSR markers. Moreover, the genetic similarity coefficient calculation used cluster analysis in NTSYSpc program version 2.0. The use of Jaccard similarity coefficients following the unweighted pair group method with arithmetic mean (UPGMA) and SAHN clustering (Sneath and Sokal, 1973) constructed a dendrogram. The variety development procedure of V-16005 appears in Table 1.

RESULTS AND DISCUSSION

Station yield trials (2016–2018)

In preliminary and regular yield trials, V-16005 gave 10.86% and 10.40% higher grain yields than local check varieties FSD-08 and PB-11, respectively (Table 2). Based on this outstanding yield and resistance against yellow rust (Yr = 0) and leaf rust (Lr = 0), its selection for multi-location yield trials at the provincial level followed.

Punjab Uniform Wheat Yield Trials (PUWYT) (2017–2018)

In this yield trial, V-16005 proved its worth against commercial check variety FSD-08 throughout Punjab when tested at 23 locations. With regular planting time, i.e., in November, it produced 4.06% more grain yield than check variety FSD-08 (Table 3).

National Uniform Wheat Yield Trial (NUWYT) (2018–2020)

The economic value of a genotype can be determined from its field performance over the years and its locations, even in the presence of yield-challenging biotic and abiotic components (Crespo-Herrera *et al.*, 2017). The advanced line V-16005 showed promising results in national trials from 2018 to 2020. This variety gave the highest yield in NUWYT under irrigated conditions when compared with check varieties FSD-08, Pakistan-13, and local check by margins of 5.64%, 6.76%, and 17.40%, respectively, during 2018–2019 (Table 4). The advance line V-16005 out-yielded the check varieties Ghazi-19, Pakistan-13, and local check by margins of 2.57%, 11.04%, and 12.03%, respectively, when tested in NUWYT Punjab in irrigated conditions during 2019–2020 (Table 5).

Agronomic Trials (2018–2020)

It is domineering to optimize the agronomic management of an advanced line to obtain its optimum potential (Malhi *et al.,* 2001). Hence, agronomic trials for determining suitable planting time and the quantity of seed and fertilizer doses per unit area also ensued for V-16005. It out-yielded the commercial check

varieties (FSD-08 and Anaj-17) by a margin of 21.55% and 10.11% during 2018–2019 in the planting time experiment. Moreover, it gave 26.51% and 5.86% better yields against the same check varieties during 2019–2020 (Table 6). Also, the two years yield performance of V-16005 indicated its suitable planting time was the first 15 days of November to obtain maximum potential grain yields. The seed rate of 100 kg ha^{-1} also showed optimum because it gave the maximum grain yield of 5029 kg ha^{-1} in the seed rate trial (Table 7). The fertilizer dose of 120-114-60 N-P-K (kg ha^{-1}) proved economical because it produced 4475 kg ha^{-1} yield during 2019–2020 (Table 7).

Table 1. Development history of Dilkash-20 (V-16005).

No.	Year	Generation/trial
1	2008–2009	Hybridization
2	2009–2016	Selection and advancement F_1 to F_7
3	2016–2017	Preliminary Wheat Yield Trial under the code V-16005
4	2017–2018	Regular Wheat Yield Trial (Irrigated) at Wheat Research Institute, Faisalabad, Under Code V-16005
5	2017–2018	Punjab Uniform Wheat Yield Trial at 23 locations in Punjab
6	2018–2019	a. NUWYT Trial, 33 Locations b. National Wheat Disease Screening Nursery, CDRI, NARC, Islamabad c. Agronomic Trials at Wheat Research Institute, Faisalabad
7	2019–2020	a. NUWYT Trial, 29 Locations b. National Wheat Disease Screening Nursery, CDRI, NARC, Islamabad c. Agronomic Trials at Wheat Research Institute, Faisalabad

Table 2. Yield performance of wheat variety Dilkash-20 (V-16005) in station yield trials.

No.	Year	Type of trial	Yield (kg ha^{-1})			
			V-16005	FSD-08	PB-11	Galaxy-13
1	2016–2017	A- trial	5150	4787	5287	4976
2	2017–2018	B-trial	5424	4750	4290	5272
Average			5287	4769	4789	5124
% Increase over checks			-	10.86	10.40	3.18

Table 3. Grain yield (kg ha^{-1}) of Dilkash-20 (V-16005) in Punjab Uniform Wheat Yield Trial 2017–2018.

No.	Locations (Punjab, Pakistan)	V-16005	FSD-08
1	Govt Seed Farm, Dhakkar Pakpattan	3037	3288
2	RSS. Bahawalnagar	3332	3822
3	Arifwala	3580	3468
4	MMRI, Sahiwal	5818	5632
5	PSC Khanewal	4152	3427
6	ARF Sargodha	4018	4252
7	RRI Kala Shah Kaku	4442	4045
8	ARF Gujranwala	4150	3918
9	ARF Kot Naina	4605	4247
10	WRI FSD	5301	5451
11	ABRI FSD	3667	4542
12	BARI Chakwal	3724	4017
13	Groundnut Research Sub Station, Attock	3925	3958
14	BARS, Fatehjang	3967	4156
15	RARI Bahawalpur	5625	6049
16	Multan	4792	4306
17	Vehari	5225	5584
18	AZRI Bhakkar	3933	3833
19	ARS Karor	3500	3667
20	Kallur Kot	5117	4333
21	WRI FSD Rainfed	3310	2952
22	RARI Bahawalpur Rainfed	3417	1500
23	NARC ISB Rainfed	5213	3584
Average		4254	4088
% Increase over check varieties			4.06

Table 4. Yield performance of Dilkash-20 (V-16005) in NUWYT Punjab, Pakistan (irrigated) during 2018–2019.

No.	Location (Punjab, Pakistan)	Yield (kg ha^{-1})			
		V-16005	FSD-08	PAK-13	Local Check
1	RARI Bahawalpur	4083.5	3333.5	2583.5	2278
2	MNS University of Agri Multan	4805.5	3805.5	4000	4500
3	Adaptive Research Farm R.Y. Khan	4166.5	3011	3472	3472
4	ARF Vehari	4375	3472.5	4056	3472.5
5	Jalla Arain Lodhran	3733.5	3616.5	3061	2939
6	Neelum Seed Research Farm, Jahania	5250	5166.5	5694.5	3639
7	WRI, Faisalabad	4735.5	5045.5	4916	4655.5
8	Govt Seed Farm, Dhakkar Pakpattan	4516	5722	4704	4840
9	RSS. Bahawalnagar	3848	4706	3490	4226
10	Depalpur	6777	6960	5886	6328
11	MMRI Yousufwala Sahiwal	6047	4907	6154	4672
12	PSC, Khanewal	5157	4499	4799	3876
13	ARF, Sargodha	4804	4187	3676	3724
14	ARF, Gujranwala	3457	3841	3864	4541
15	Mandi Bahauddin	4591	4610	3667	4175
16	ARF Kot Naina, Shakargar	3683	3896	3951	4113
17	RRI, Kala Shah Kaku	3910.5	3804.5	4079	2083
18	AZRI Bhakkar	5014	4472	4528	4064
19	ARF, Karor	5166.5	4643.5	5375	4202
20	GRS, Kallur Kot	5858.5	4855.5	5394.5	4262.5
Mean (Pooled data over 20 locations)		4722.9	4470.7	4423.8	4023.1
% Increase over check varieties		-	5.64	6.76	17.40

Table 5. Yield performance of Dilkash-20 (V-16005) in NUWYT Punjab, Pakistan (Irrigated) during 2019–2020.

No.	Locations (Punjab, Pakistan)	Yield (kg ha^{-1})			
		V-16005	Ghazi-19	PAK-13	Local Check
1	RARI, Bahawalpur	3944	3278	3833	3612
2	MNS University of Agri. Multan	4500	4112	4167	4062
3	Adaptive Research Farm, R.Y. Khan	4500	5723	4334	4361
4	Alipur, Muzaffar Garh	5593	5583	5685	6045
5	Jahanian	6389	5861	4028	4583
6	Khanpur	5857	6147	6217	5388
7	WRI, Faisalabad	4778	4763	4219	4034
8	Govt. Seed Farm, Dhakkar, Pakpattan	5619	5626	5135	5178
9	RSS, Bahawalnagar	5614	5114	5289	4373
10	Depalpur	5899	5217	4464	5648
11	MMRI, Yousufwala, Sahiwal	4466	4399	3557	3936
12	PSC, Khanewal	5533	5057	4022	4811
13	ARF, Sargodha	3976	3918	3462	3812
14	ARF, Gujranwala	4929	4594	4577	3390
15	Mandi Bahauddin	3734	5110	3207	3540
16	Kot Naina, Shakargarh	3042	2982	3697	3002
17	RRI, Kala Shah Kaku	4089	3630	4070	3149
18	AZRI, Bhakkar	4192	4142	4740	4207
19	GRS, Kallur Kot	4698	4905	4425	4792
20	UAF	3780	2601	2563	2999
Mean (Pooled data over 20 locations)		4757	4638	4284	4246
% Increase over check varieties			2.57	11.04	12.03

Table 6. Yield performance of Dilkash-20 (V-16005) in sowing date trials during 2018–2019 and 2019–2020.

No.	Sowing date	2018–2019 Yield kg ha^{-1}			2019–2020 Yield kg ha^{-1}		
		V-16005	FSD-08	Anaj. 17	V-16005	FSD-08	Anaj.17
1	Oct 20	-	-	-	4921	3380	5129
2	Nov 01	5015	5203	5083	4655	4525	4472
3	Nov 10	5451	5315	5430	5256	3723	4429
4	Nov 20	4204	4029	4174	4491	3913	4124
5	Nov 30	4445	2974	3793	3846	2999	3642
6	Dec 10	4495	2959	3649	3774	2735	3620
7	Dec 20	4190	2899	3580	3731	2838	3423
8	Dec 30	3971	2758	3144	3414	2834	3359
	Average	4539	3734	4122	4261	3368	4025
% Increase over check			21.55	10.11	-	26.51	5.86
$LSD_{0.05}$ kg ha^{-1}		Sowing dates = 90, Varieties = 118, Interaction = 312			Sowing dates = 153, Varieties = 166, Interaction = 440		

Table 7. Seed rate and levels of fertilizer's impact on grain yield (kg ha^{-1}) of Dilkash-20 during 2019–2020.

Seed rate (kg ha^{-1})	Yield kg ha^{-1}		Fertilizer level (NPK kg ha^{-1})	(Yield kg ha^{-1})	
	V-16005	FSD-08		V-16005	FSD-08
75	4782	4139	0-0-0	3596	3342
100	5029	4480	120-90-60	4321	3994
125	4866	4350	120-114-60	4475	4501
150	4760	4191	160-171-60	4410	4105
Average	4859	4290	Average	4201	3985
$LSD_{0.05}$ kg ha^{-1}	Seed rates = 76, Varieties = 123, Interaction = 198		$LSD_{0.05}$ kg ha^{-1}	Fertilizer level = 74, Varieties = 88, Interaction = 191	

Disease screening studies

Stripe and leaf rust are becoming more dangerous and have caused many economic losses to the wheat crop. The CDRI, Islamabad, screened this genotype V-16005 against different rusts in the National Wheat Disease Screening Nursery (NWDSN) at various locations for two years, from 2018 to 2020. The Relative Resistance Index (RRI) of leaf rust was 8.48 and 7.93 for 2018–2019 and 2019–2020, respectively (Table 8), while RRI for yellow rust was at 6.4 (Table 9). These results indicated that V-16005 or Dilkash-20 had performed best in the field and had shown a durable resistance against different rusts in varied climates. Hence, this genotype needs further studies in other wheat breeding programs.

Quality parameters

Dilkash-20 has shown good quality traits in a series of experiments compared with the existing commercial check cultivars (Table 10). Different quality parameters like 1000-grain weight (45.7 g), test weight (72.1 kg/hl), protein content (15.1%), starch content (52.7%), and gluten contents (28.7%) recorded for Dilkash-20 have met the quality standards of wheat grains like FSD-08 (Hussain *et al*., 2009).

Botanical attributes of Dilkash-20

Dilkash-20 (V-16005) has been approved and recommended for general cultivation by the Punjab Seed Council to replace the existing commercial varieties like Ujala-16 and Faisalabad-08, which dominate the major wheat growing area and currently have become susceptible to different rust races throughout the country. The botanical description of all the vegetative plant parts of Dilkash-20 appear in Table 11. Dilkash-20 has a medium height (105–115 cm), and the seedling has no anthocyanin pigmentation. The growth habit of V-16005 is semi-erect at both seedling and booting stages, with very light waxiness on the stem, about 2.2 mm in diameter that turns yellowish white at maturity. It has the highest number of tillers per m^2 (about 400–425 tillers), and erect flag leaves with waxiness. Its auricle has no anthocyanin pigmentation and is hairy (Table 11). The reproductive or spike-related

Table 8. Leaf rust data of LDSN and NWDSN of Dilkash-20 (V-16005).

Variety	Year	Faisalabad	Islamabad	Bahawalpur	Kala Shah Kaku	
V-16005	2018–2019	0	0	0	0	
Morocco		70S	10S	80S	50S	
V-16005	2019–2020	30MRMS	0	0	5MRMS	
Morocco		90S	5S	90S	70S	
National Wheat Disease Screening Nursery (NWDSN)						
Variety	Year	Sakrand	Tandojam	Bahawalpur	Faisalabad	RRI
V-16005	2018–2019	0	TMSS	0	10S	8.48
Morocco		100S	100S	60S	70S	-
V-16005	2019–2020	TMSS	10MSS	10MSS	10MSS	7.93
Morocco		100S	100S	90S	90S	-

Table 9. Yellow rust data of LDSN and NWDSN of Dilkash-20 (V-16005).

Variety	Year	Faisalabad	Islamabad	Bahawalpur	Kala Shah Kaku
V-16005	20118–2019	5MS	40MR	20MRMS	0
Morocco		90S	100S	80S	40S
V-16005	2019–2020	TMRMS	5RMR	5MR	10MRMS
Morocco		80S	100S	70S	50S
National Wheat Disease Screening Nursery (NWDSN)					
Variety	Year	Nowshera	Peshawar	Islamabad	RRI
V-16005	2018–2019	50MRMS	40MRMS	40MRMS	6.4
Morocco		100S	100S	100S	-

Table 10. Quality characteristics of cultivar of Dilkash-20 (V-16005).

Quality characters	Normal Planting			
	V-16005	FSD-08	Galaxy-13	Anaj-17
1000-grain weight (g)	45.7	45.0	42.4	41.7
Test weight kg/hl	72.1	71.5	70.4	72.3
Protein (%)	15.1	14.2	13.3	14
Starch (%)	52.7	52.3	53.6	52.8
Gluten (%)	28.7	27.7	26.3	26.3

Table 11. Botanical description and other characteristics of Dilkash-20 (V-16005).

Vegetative Part (Plant Characteristics)					
1	Variety	V-16005	5.6	No. of Tillers per m^2	400–425
1.1	Parentage	WBLL*2/4/SNI/TRAP#1/3/KSUZ/5/ PB.96//LU26/HD2179	6	*Stem characteristics*	
1.2	Pedigree/Selection	PB.35237-0A-0A-5A-0A	6.1	Anthocyanin	Absent
1.3	Species	*Triticum aestivum L.*	6.2	Stem waxy bloom	Week waxy
1.4	Breeder	Selection	6.3	Wall thickness	Thin
1.5	Maintainer	WRI, Faisalabad	6.4	Stiffness	Thin
1.6	Comparable variety	Faisalabad.08	6.5	Color	Dark Green
1.7	Area of adaptation	Irrigated areas of Punjab	6.6	Diameter	2.2 mm
2	*Maturity duration*	Medium	6.7	Inter-nodal length (Upper internode)	20-23 cm
3	*Sowing time*	10th to 30th December	6.8	No. of nodes from above soil	4-5
4	*Seedling characteristic*		7	*Flag leaf characteristics*	
4.1	Seedling Growth Habit	Semi Erect	7.1	Attitude	Erect
4.2	Coleoptile color	White	7.2	Twist	Present week
4.3	Seedling anthocyanin	Absent	7.3	Length	24-26 cm
5	*Plant Characters*		7.4	Width	26-28 mm
5.1	Plant Height	105-115 cm	7.5	Sheath waxy bloom	Waxy Present
5.2	Taller than cultivar	Faisalabad-08, Ujala-16	7.6	Sheath Hairiness	Absent
5.3	Shorter than	Galaxy-13	8	*Auricle*	
5.4	Growth habit at booting	Erect	8.1	Hairiness	Present
5.5	Color at booting	Green	8.2	Anthocyanin	Absent

Table 11 (cont'd).

Reproductive Part (Spike Characteristics)					
9	*Ear*		13	***Glume***	
9.1	Emergence	119 days	13.1	Length	8.60 mm
9.2	Waxy bloom at anthesis	Weak	13.2	Width	5.80 mm
9.3	Color at maturity	Yellowish white	13.3	Attachment	Strong
9.4	Size	Small to medium	13.4	Shoulder width	Narrow to medium
9.5	Shape	Tapering	13.5	Shoulder shape	Elevated
9.6	Density	Dense	13.6	Beak length	7-10 mm
9.7	Awnedness	Awned	13.7	Beak shape	Elevated
9.8	Supernumerary spikelets	Absent	13.9	Pubescence	Absent
9.9	Speltoides	Absent	13.10	Surface	Smooth
9.1	Shattering	Absent	13.11	Internal hair	Absent
9.11	Kink/twist	Absent	13.12	Internal imprint	Absent
10	***Awns at maturity***		13.13	Keel spicules	Present
10.1	Distribution	Whole	14	***Seed***	
10.2	Length	Medium	14.1	Color	Amber
10.3	Color	Yellowish white	14.2	Shape	Ovate
10.4	Habit	Semi erect	14.3	Length	7 mm
10.5	Awns spicules	Present	14.4	Width	3 mm
11	**Anther**		14.5	Thickness	Thick
11.1	Anther color at flowering	Yellow	14.6	Size	Medium
12	***Rachis***		14.7	Germ size and shape	Medium
12.1	Hairiness of apical segment	Medium	14.8	Brush	Short
12.2	Hairiness of margin	Medium	14.9	Groove	Intermediate
12.3	Length	10-12 cm	14.10	Hardiness	Hard
12.4	Width	2.5 to 3.00 cm	14.11	Surface	Rough
12.5	No. of segments	15-18	14.12	No. of Seeds/ear	50

Figure 1. Grains and spikes of Dilkash-20.

characteristics are botanically described in Table 11. The ears are dense and resistant to shattering and have awns of yellowish and white color of medium length while having a tapering shape that can produce about 50 seeds per ear. Rachis has 15–18 segments and its length is about 10–12 cm. The days to heading are about 119 days, while days to maturity may range from 143 to 152 days. The glume is 8.6 mm long and 5.8 mm wide and has a strong attachment with a stem. The shoulder of the glume slightly elevates that ranges between narrow to medium wide.

The 7–10 mm long beak of the glume is free from any imprints and internal hairs, and the elevated glume is a smooth surface. The intermediately grooved, amber-colored ovate seeds are medium to bold in size and have a short brush with rough surfaces (Table 11). Figure 1 represents the grains and spikes

of Dilkash-20. Its chapatti and bread-making quality is excellent and thus best for industrial use. In short, its durable tolerance against the local rust races, stable and impressive yield performance in different sowing times, great response to different fertilizers doses, and promising yield performance in different agro-ecological zones of irrigated areas of Punjab, Pakistan made it able to win its approval for general cultivation throughout the province by the Punjab Seed Council during the year 2021. This indigenously developed new wheat variety shall prove a good addition to the commercial selections of the region and an excellent source of rust resistance for the breeding program of the institute.

DNA finger printing of Dilkash-20

Among 233 SSR markers, 12 gave no amplification, and one was monomorphic, while 220 were polymorphic, which amplified 2382 alleles. The SSR marker (WMS-295) amplified a maximum number of alleles (31). On average, 10 alleles occurred per locus, higher than previously reported results (Al-Ashkar *et al.,* 2020). Calculating the polymorphic information content of the markers also ensued to study the effectiveness of SSR markers, which ranged from 0.1 to 0.80, also higher than previously reported results (Al-Tamimi and Al-Janabi, 2019).

Employing cluster analysis drew a dendrogram-based similarity/dissimilarity coefficient using the UPGMA algorithm, which showed variable genetic similarity of 0.54 to 0.79 among wheat genotypes (Figure 2). Genotypes were broadly classified to two major clusters: genotypes Akbar-19, Dilkash-20, AAS-11, TWS-15137, Bhakkar-2020, and Gold-16 placed in one cluster, while Chakwal-50, Galaxy-13, Anja-17, AARI-11, FSD-08, Johar-16, Fakhar-e-Bhakkar, Ujala-16, Barani-17, Ihsan-16, Dharabi-11, Millat-11, Punjab-11, and Ghazi-19 placed in the other cluster. The candidate variety Dilkash-20 varied significantly from many of the registered varieties, showing 46% dissimilarity at 2382 genetic loci. These dissimilarities percentages show that Dilkash-20 is a distinct variety from previously registered varieties and has a diverse genetic background (Iqbal *et al.,* 2021a, b; Jamil *et al.*, 2021a, b, c).

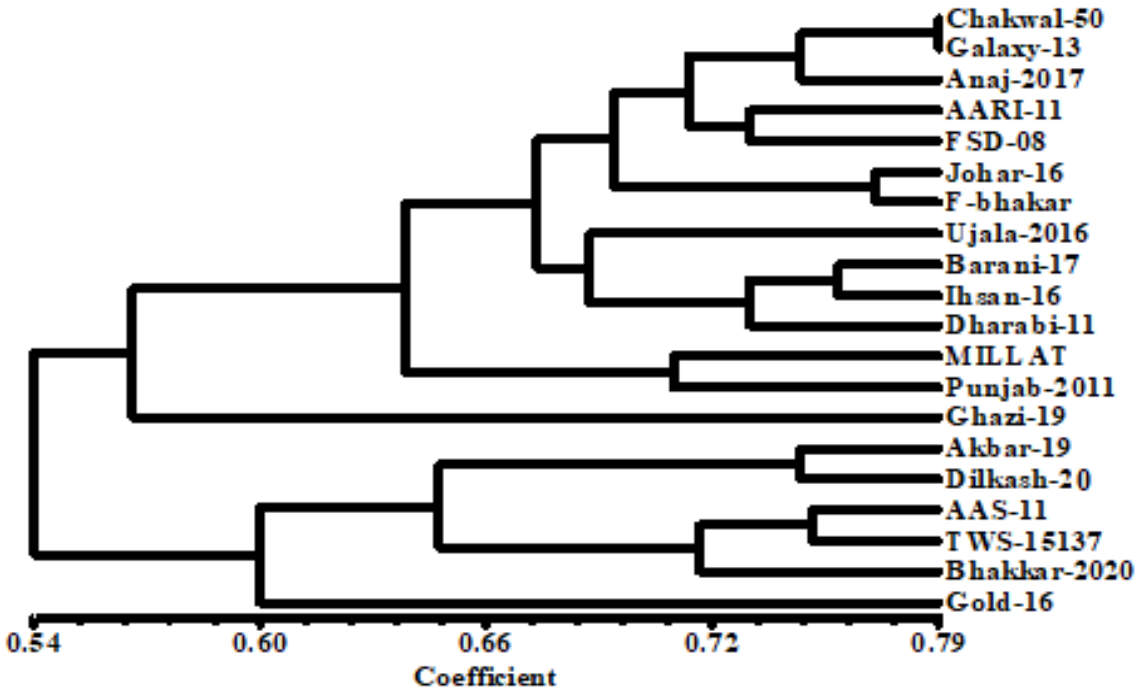

Figure 2. Dendrogram of 20 wheat genotypes including Dilkash-20.

CONCLUSIONS

The WRI has been a premier Institute in the field of wheat varietal development in Pakistan. Pak-81, Inqilab-91, Seher-06, Faisalabad-08, and Galaxy-13 remained as the mega-wheat varieties covering major wheat-growing areas not only in Punjab but the whole of Pakistan. These varieties performed best for food security sustainability in Pakistan, yet with time, these varieties became vulnerable to different rust races. Dilkash-20 is a new addition to continue the legacy of WRI in developing bumper wheat varieties. Dilkash-20 is an indigenously developed new wheat variety with high yield potential than the previous commercial selections. It flaunts resistance to all rust types, having excellent quality characters. It got approved for commercial cultivation in the irrigated areas of Punjab, Pakistan.

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