



# Durum-21: A New High-Yielding and Good Quality Durum Wheat Variety Suitable for Pasta Production

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**Abstract:** Durum-21 (D-21) is a high-yielding, disease resistant with better-quality traits variety, developed by Wheat Research Institute Faisalabad. This variety is mainly developed for industrial purposes for pasta production. Worldwide, durum wheat is utilized for pasta production; but in Pakistan, due to a lack of research work and non-availability of quality seeds of durum wheat, bread wheat is being utilized for pasta production. D-21 is developed with the breeding code of D-21 having parentage of FKN/3/2\*FR//KAD/GB/4/BB/CHA/5/AS-2002 with pedigree as PB20733-1a-2a-2a-0a-0a-19a-0a. The candidate line D-21 was developed by crossing a germplasm accession with approved bread wheat variety AS-02. The genotype was further evaluated over multiple locations in Punjab Pakistan for yield and yield-related attributes in the station, provincial, and national uniform durum yield trials executed by Wheat Research Institute (WRI), Faisalabad during 2015-20. The promising line out yielded the two commercial check varieties D-97 and Fsd-2008 by 1.42 % in the provincial yield trial and 4.2 % in the national yield trial. D-21 had desirably medium to tall plant height (96-100 cm) without anthocyanin pigment. It has erected to semi-erect growth habit at the seedling stage. Its color is green with medium waxiness on stem and yellowish-white at maturity. Its 1000-grain weight ranged from 38.9 to 39 g while the test weight remained from 69 to 78.5 g. The protein contents were 13.1 to 14.95 %; which is higher than the two checks (D-97 and Fsd-2008). Due to its better grain yield and promising nutritional and quality parameters, it was approved in the year 2021 for cultivation all over the country.

**Keywords:** Durum, Adaptability, Pasta, Pigmentation

## 1. INTRODUCTION

Durum wheat (*Triticum turgidum* L.) is a tetraploid species of wheat that is primarily grown for industrial purposes. It is mainly grown in Mediterranean countries, including the Middle East, North America, and North Africa [1] Durum wheat offers a great advantage over bread wheat in a number of aspects. Durum wheat has A and B genomes with 28 chromosomes while bread wheat contains A, B, and D genomes with 46 chromosomes [2] Durum wheat is much harder than bread wheat which requires more thorough grinding to produce semolina and flour. Durum wheat dough contains a strong visco-elastic protein complex known as gluten which makes it more suitable for pasta production, on the other hand, bread wheat is mainly utilized for

domestic purposes to make bread [3]. A typical durum wheat grain is vitreous, very hard, amber in colour, and contains 2-3 % more protein and gluten content as compared to bread wheat [4]. Besides high protein and gluten content it is also rich in carotenoid, folate, iron, calcium, and dietary fibre [5]. Durum wheat was grown on an area of over 16 million hectares with an annual global production of over 38 million tonnes [6]. The largest producing countries of durum wheat are including Turkey and Canada with an estimated area of more than 2 million ha of each followed by Italy, Algeria, and India [7]. Due to its economic importance and unique properties, it is used to make a wide range of food products including semolina, pasta, noodles, burghul wheat, Couscous, and desserts. Durum wheat is milled into a small granular form that is

known as semolina and that is mainly utilized for pasta production [8].

Different value-addition industries of wheat require specific quality wheat grains. The most widely used wheat in pasta products is durum wheat [9]. The international food industry, involved in pasta products uses durum wheat flour for making quality products. Pakistan has a transforming economy hosting many western food chains across the country. Changing lifestyles and tastes of the population suggest increasing demand for pasta products. Currently, durum wheat is being imported by all pasta industry stakeholders on account of the non-availability of high-yielding durum wheat variety and milling units. Due to increasing demand for pasta products and their premium price, milling units are being established across the country and research work has been initiated for the development of good quality durum variety. The provision of high-quality durum variety will help to reduce the import bill through local production of durum wheat flour. The current research work was conducted to develop high-yielding, better quality, and disease-resistant durum wheat variety that can be utilized in industry for pasta production.

## 2. MATERIALS AND METHODS

The present research work was conducted at Wheat Research Institute, Faisalabad Pakistan along with various locations in the province of Punjab during 2015-2020. The D-21 has parentage of FKN/3/2\*FR//KAD/GB/4/BB/CHA/5/AS-2002 with pedigree as PB20733-1a-2a-2a-0a-0a-19a-0a. Durum wheat line D-21 is developed by crossing a germplasm accession with approved bread wheat variety AS-02. The proposed variety has an edge in yield over Durum-97 with genetic resistance to diseases. This variety is suitable for planting from 1<sup>st</sup> to 20<sup>th</sup> November in Punjab province. The D-21 was evaluated for higher grain yield, disease resistance, and other attributes at station yield trials. Station yields trials further consist of preliminary and regular yield trials. Both these trials were conducted at WRI, Faisalabad. Based on higher yield performance in generation trials D-21 was tested in a preliminary yield trial conducted during 2016-17. The trial was consisting of 10 entries along with one check variety D-97

following RCBD design. The experimental plot size was maintained at 8.1 m<sup>2</sup> with 6 rows and three replications. The R×R distance was kept at 27 cm and the length of each row was maintained by 5m. This line is then promoted into a regular yield trial that was comprised of 16 entries along with 2 check varieties Fsd -2008 and D-97. The trial was laid out under RCBD, by maintaining the net plot size of 8.1 m<sup>2</sup> during 2017-18. The promising line was then promoted into Provincial Uniform Durum Yield Trial (PUDYT) to check the adaptability and stability over multiple locations throughout the province of Punjab. The D-21 was compared with two local checks Fsd-08 and D-97 in Provincial Uniform Durum Yield Trial. This genotype was again sent in National Uniform Durum Yield Trial (NUDYT) in the next two consecutive years (2018-19, 2019-20) to test the adaptability and yield stability of a mega environment throughout Pakistan. The grains of D-21 were sent to Crop Disease Research Institute (CDRI), NARC, Islamabad to screen out against the indices of leaf and yellow rust during the NUDYT testing years. All other management practices were accomplished as per crop recommendation. Seed samples of the candidate line were taken from (PUDYT 2017-18) for the assessment of the quality analysis from Cereal Technology Laboratory WRI, Faisalabad according to the standard protocol of American chemists [10] & [11]. The crop development stages were observed continuously until crop maturity and grain retentions in mature spike during every crop cycle. The brief development history of D-21 is mentioned in Table 1.

## 3. RESULTS AND DISCUSSION

### 3.1. Preliminary Yield Trial (2015-16)

The preliminary yield trial was conducted at Wheat Research Institute Faisalabad during 2015-16. Ten (10) entries along with three replications were tested and compared with one local check variety durum-97 as shown in Table 2. The advanced line D-21 yielded 3931 kg/ha<sup>-1</sup>. It performed better than the check variety in the preliminary yield trial and gave 8.90 % higher yield than D-97. Therefore, it was re-evaluated for yield and stability in regular yield trials (B- trial).

**Table 1.** Development history of “D-21”

S. No.	Year	Generation
1	2007-08	Hybridization
2	2008-15	F <sub>1</sub> to F <sub>7</sub>
3	2015-16	Preliminary Durum Wheat Yield Trial under the code D-21
4	2016-17	Regular Wheat Yield Trial at Wheat Research Institute, Faisalabad, under code D-21
5	2017-18	Punjab Uniform Durum Wheat Yield Trial
6	2018-19	National Uniform Durum Yield Trial
7	2019-20	National Uniform Durum Yield Trial

### 3.2. Regular Yield Trial (2016-17)

The regular yield trial was conducted during 2016-17 at WRI, Faisalabad to check the yield performance of candidate line D-21. The results of this trial indicated that the advanced line D-21 produced 3856 kg ha<sup>-1</sup> with an 8.90 % higher yield than D 97. Moreover, the disease data also indicated that the advanced line was ultimately resistant to leaf and yellow rusts as mentioned in Table 2. Therefore, it was promoted to Punjab Uniform Durum Yield Trial during 2017-18 for yield stability and adaptability evaluation.

### 3.3. Punjab Uniform Wheat Yield Trial (2017-18)

Based on the better performance of two consecutive years in station yield trial, the advanced line D-21

was tested for wider adaptability across a mega environment in a provincial uniform durum yield trial (PUDYT) over 20 locations in irrigated areas of Punjab during 2017-18. The overall yield performance of different advanced lines at various locations in Punjab is given in Table 3. The proposed line D-21 out yielded the check variety D-97 by 1.45 % at different locations in Punjab. Moreover, the candidate line also showed resistance against leaf and yellow rust. On the basis of tabulated and diseased screening data, this line was further tested in National Uniform Durum Yield Trial (NUDYT) during 2018-19.

### 3.4. National Uniform Durum Yield Trial

A good variety is that which perform better with respect to yield and yield-related attributes under a diverse environment. Development of higher

**Table 2.** Grain yield of “D-21” in station yield trials

Sr. No.	Year	Trial name	Grain Yield (kg ha <sup>-1</sup> )	
			D-21	Durum 97
1	2015-16	PYT (Preliminary yield trial)	3937	3531
2	2016-17	RYT (Regular yield trial)	3856	3625
		Average	3896	3578
		<b>% Increase Over Durum-97 (Check)</b>		<b>8.90</b>

**Table 3.** Grain yield of “D-21” in PUDYT during 2017-18

Sr. No.	Location	Grain yield (kg ha <sup>-1</sup> )	
		D-21	D-97
1	Govt Seed Farm, Dhakkar Pakpattan	1831	1396
4	MMRI, Sahiwal	2978	2729
5	PSC Khanewal	1474	1289
6	ARF Sargodha	1779	2399
7	RRI Kala Shah Kaku	2020	2123
	Average	3361	3312
	<b>% Increase over check</b>		<b>1.45</b>

grain yield across mega environments is very critical. Development of characters in a genotype require favorable genetic recombination along with multilocation testing at the national level against a wide range of variation in biotic and abiotic stress factors. The promising line D-21 gave a higher yield in two consecutive years as compared to local checks Fsd-2008 and D-97 during (2018-19 and 2019-20) by 3.5 and 4.8 % respectively (Tables 4 and 5).

### 3.5. Agronomic Trials

To optimize sowing time, seed rate and fertilizer levels of advanced line D-21, the agronomic trials were conducted at WRI, Faisalabad during 2018-

20. The promising line D-21 performed better with respect to planting time with a notable margin of 9.7 % in 2018-19 and 12.8 % again in 2019-20 over the check varieties as mentioned in Table 6. To assess the best seed rate for D-21 another agronomic trial was performed at WRI, Faisalabad. The advanced line D-21 performed better at the seed rate of 150 Kg ha<sup>-1</sup> in both the years. It out yielded the local checks by a margin of 2.8 and 4.7 % respectively as indicated in Table 7. The third agronomic trial was conducted related to fertilizer application. To optimize the level of fertilizers, different doses of fertilizers were maintained. Line D-21 produced better at the rate of N-P-K 120-114-60 NPK (Kg ha<sup>-1</sup>). It showed 13.9 & 9.3 % more yield in 2018-19 and 2019-20 as compared to local checks (Table 8).

**Table 4.** Grain yield of “D-21” in NUDYT during 2018-19

S. No.	Location	Grain Yield (kg ha <sup>-1</sup> )	
		D-21	FSD-08
1	CCRI, Nowshera	2473	2658
2	WRI, Faisalabad	3948	4124
3	ARI, Quetta	3273	3262
Average		3231	3348
<b>% Increase over check</b>		<b>3.5</b>	

**Table 5.** Grain yield of “D-21” in NUDYT during 2019-20

S. No.	Location	Grain Yield (kg ha <sup>-1</sup> )	
		D-21	Durum-97
1	Arid Zone Researc Institute, Bhakkar	1764	1715
2	Wheat Research Institute, Faisalabad	4059	4194
3	Nuclear Institue Agricultur, Tandojam	3911	4827
4	Wheat Program, NARC, Islamabad	4031	3263
5	Barani Agricultural Research Institute, Chakwal	3170	4507
Average		3996	3812
<b>% Increase over check</b>		<b>4.8</b>	

**Table 6.** Grain yield of “D-21” in sowing date trials

S. No.	Grain Yield (kg ha <sup>-1</sup> )				
	2018-19		2019-20		
	Date	D-21	Local Check	D-21	Local Check
1	Nov 01	4109	3919	3454	3280
2	Nov 20	4020	3512	3976	3312
3	Dec 10	3360	3035	3291	2908
Average		3829	3488	3573	3166
<b>% Increase over checks</b>		<b>9.7</b>		<b>12.8</b>	

**Table 7.** Grain yield of “D-21” in seed rate trials

S. No.	Seed rate (kg ha <sup>-1</sup> )	Grain Yield (kg ha <sup>-1</sup> )			
		2018-19		2019-20	
		D-21	Local Check	D-21	Local Check
1	100	3795	3587	3675	3496
2	125	4080	3989	3967	3800
3	150	4100	4069	4080	3899
	Average	3991	3881	3907	3731
	<b>% Increase over checks</b>		<b>2.8</b>		<b>4.7</b>

**Table 8.** Yield response of D-21 to different fertilizer doses

S. No.	NPK (kg ha <sup>-1</sup> )	Grain Yield (kg ha <sup>-1</sup> )			
		2018-19		2019-20	
		D-21	Local Check	D-21	Local Check
1	85-85-0	2955	2400	3210	2980
2	120-114-0	3502	3060	2978	2567
3	120-114-60	4200	3895	3998	3767
	Average	3552	3118	3395	3104
	<b>% Increase over checks</b>		<b>13.9</b>		<b>9.3</b>

### 3.6. Disease Screening Studies

The advanced line D-21 was screened against leaf and yellow rust by Cereal Disease Research Institute Islamabad (CDRI) by the inclusion in National Wheat Disease Screening Nursery (NWDSN) at various locations for two consecutive years 2018-19 and 2019-20. The advanced line D-21 showed high resistance against yellow and leaf rust for two consecutive years. Moreover, it also showed zero % terminal reaction as compared to commercial check variety which showed high susceptibility with

terminal rust reaction of more than 50 S in 2018-19 and more than 20 S in 2019-20 as illustrated in tables 9 and 10. The obtained disease screening results of line D-21 revealed that this genotype was resistant to yellow and leaf rust and could be used to develop leaf and yellow rust resistance sources in future breeding programs.

### 3.7. Quality Related Characteristics

Different quality-related parameters of D-21 were evaluated. Durum wheat is mainly utilized in the industry for pasta production as it contains

**Table 9.** Yellow rust data of LDSN at different locations

Variety	Year	Faisalabad	Islamabad	Bahawalpur	Kala Shah Kaku
D-21	18-19	0	0	0	0
Morocco		90S	100S	80S	40S
D-21	19-20	0	0	0	0
Morocco		80S	100S	70S	50S

**Table 10.** Leaf rust data of LDSN at different locations

Variety	Year	Faisalabad	Khanewal	Bahawalpur	Kala Shah Kaku
D-21	18-19	0	0	0	0
Morocco		60S	30S	70S	50S
D-21	19-20	0	0	0	0
Morocco		70S	20S	50S	40S

more amount of gluten and protein content. High percentage of gluten and protein in durum grain makes it better for pasta production. Its 1000-grain weight was 38.9-39 g and the test weight remained 69-78.5 g. The protein contents were 13.1 to 14.95 % which was higher than the two checks D-97 and Fsd-2008. Moreover, its pasta and noodles making quality parameters were also promising as compared to local checks variety Fsd-2008 and D-97 (table 11).

### 3.8. Botanical Attributes of D-21

The new variety D-21 had desirably medium to tall (96-100 cm). Anthocyanin pigment was absent at seedling as well as at maturity. It has an erect to semi-erect growth habit. Its color is green with medium waxiness on the stem and yellowish-white at maturity. Its stem is stiff enough that provide resistance against lodging. A number of tillers vary from 350 to 450 m<sup>2</sup>. It contains a waxy flag leaf with an erect orientation of 27 to 30 cm in length and 1.9 to 2.1 cm in width. Hairiness auricle was present with weak anthocyanin pigmentation. It has awns of medium length, shattering resistant, dense ear with small to medium in size having 55-65 seeds per ear. Rachis is 10-12 cm in length with 16-18 segments. It takes 110-120 days for heading and it matures in 150-60 days. Its glume length is about 13.5-14.5 and its width is 3.8-4.0 cm with strong attachment. Shoulder of the glume was narrow to medium and glume beak was straight and its pubescence was absent. The glume surface was smooth and without internal hairs and imprints. It has a medium sized seed with an ovate shape and amber in color with a medium brush and opaque surface with an intermediate groove. The germ size of the seed was medium. Its bread and chapatti-making quality were good to very good as mentioned in Table 12. Moreover, it is highly resistant against the leaf and yellow rust races and gave good yield

under different locations in Punjab and Pakistan. It also showed a good response against fertilizer applications having better adjustment to different ecological zones. Similar observations were reported by Nilusha *et al.* [9]. Botanical description of Durum-21 is given in Table 12 and a pictorial view of the plant, grain, and spike is presented in Figure 1.

### 3.9. DNA Finger Printing of Durum-21

The Cluster analysis was carried out among check variety Durum-21 along with advanced lines viz. D-18801, D18802, D-18810, D-18812, D18815, D-18830, D18840, D-18847, D-18708, D18721, D-17728 and D-97 against the 50 SSRs markers to draw a dendrogram based on similarity/dissimilarity coefficient using UPGMA algorithm which showed variable genetic similarity 0.76 to 0.90 among different durum genotypes (Figure 2). The Cluster analysis differentiated all the genotypes into two major clusters, cluster one having genotypes viz. D-18801, D-18812, D-18815, D-18840, D-17728, D-97, D-18847 and D-18708. However, genotypes D-18802, Durum-21, D-18721, D-18810, and D-18830 were placed in the second major cluster. Durum-21 was found significantly different from many of the other durum genotypes i.e., 29 % dissimilar from D-18801, 10 % from D-18802, 16 % from D-18810, 25 % from D-18812, 31 % from D-18815, 18 % from D-18830, 30 % from D-18840, 25 % from D-18847, 24 % from D-18708, 12 % from D-18721, 23 % from D-18778 and 20 % from Durum-97. These dissimilarity values confirmed that Durum-21 is a distinct variety and possesses a diverse genetic background [12, 13].

## 4. CONCLUSION

Wheat Research Institute Faisalabad is one of the renowned research institutes of the world as it is

**Table 11.** Quality characteristics of D-21 in NUDYT 2018-19

Quality characters	NUDYT 2018-19			Standards
	D-21	Fsd-08	D-97	
1000-grain weight (g)	38.9-39.0	35.1-37.6	37.25-38.10	≥30
Test weight kg/hl	69.0-78.5	66.6-73.6	63.89-64.25	≥68
Protein (%)	13.1-14.95	14.05-14.45	11.9-12.3	≥12
Pasta quality	Good	Poor	Fair	
Noodles quality	Good	Poor	Fair	

Table 12. Botanical description of Durum-21

Botanical description of Durum-21					
1.	<b>Variety</b>	<b>D-21</b>	10.2	Length	Medium
1.1	Parentage	FKN/3/2*FR//KAD/GB/4/BB/CHA/5/AS-2002	10.3	Color	Yellowish whit
1.2	Pedigree	PB20733-1a-2a-2a-0a-0a-19a-0a	10.4	Habit	Erect
1.3	Species	<i>Triticum durum</i> L.	<b>11</b>	<b>Anther</b>	
1.4	Breeder	Hybridization	11.1	Anther color at flowering	Yellow
1.5	Maintainer	WRI, Faisalabad	<b>12.</b>	<b>Rachis</b>	
1.6	Comparable variety	Durum-97	12.1	Hairiness of convex surface of the apical segment	Medium
1.7	Area of adaptation	All Punjab	12.2	Hairiness of margin	Medium
1.8	Approval status	Approved	12.3	Length	5.2-6 cm
<b>2.</b>	<b>Maturity duration</b>	150-160 Days	12.4	Width	3.8-4.0 mm
<b>3.</b>	<b>Sowing time</b>	November 01 to December 10	12.5	No. of segments	16-18
<b>4.</b>	<b>Seedling anthocyanin</b>	Absent	<b>13</b>	<b>Glume</b>	
4.1	Coleoptile color	Colorless	13.1	Length	13.5-14.5 mm
<b>5.</b>	<b>Plant</b>		13.2	Width	3.8-4.0 mm
5.1	Growth at seedling	Semi erect	13.3	Attachment	Medium
5.2	Growth at booting	Semi erect	13.4	Shoulder width	Narrow
5.3	Color at booting	Green	13.5	Shoulder shape	Elevated
5.4	Tillers per m <sup>2</sup>	350-450	13.6	Beak length	2.5-3.0 mm
5.5	Height	96-100 cm	13.7	Beak shape	Straight
<b>6.</b>	<b>Stem</b>		13.9	Pubescence	Absent
6.1	Waxy bloom	Medium	13.10	Surface	Smooth
6.2	Anthocyanin	Absent	13.11	Internal hair	Absent
6.3	Wall thickness	Intermediate	13.12	Internal imprint	Absent
6.4	Stiffness	Intermediate	13.13	Keel spicules	Present
6.5	Color	Green	<b>14.</b>	<b>Seed</b>	
6.6	Diameter	3-4 mm	14.1	Color	Amber
6.7	Peduncle length	42-45 cm	14.2	Shape	Ovate
6.8	Nodes/stem	4-5	14.3	Length	6.6-7.5 mm
<b>7.</b>	<b>Flag leaf</b>		14.4	Width	3.5-3.9 mm
7.1	Attitude	Erect	14.5	Thickness	2.7-2.8 mm
7.2	Twist	Medium	14.6	Size	Medium
7.3	Length	27-30 cm	14.7	Germ size	Medium
7.4	Width	1.9-2.1 cm	14.8	Brush	Medium
7.5	Sheath waxy bloom	Medium	14.9	Groove	Intermediate
<b>8.</b>	<b>Auricle</b>		14.10	Hardiness	Hard
8.1	Hairiness	Absent	14.11	Surface	Opaque
8.2	Anthocyanin	Weak	14.12	1000 kernel weight	37.13-39.24 g
<b>9.</b>	<b>Ear</b>		14.13	Seeds/ear	55-65
9.1	Emergence	110-120 Days	14.15	Protein content	12-13%
9.2	Waxy bloom at anthesis	Medium	<b>15.</b>	<b>Baking</b>	
9.3	Color at maturity	Yellowish white	15.1	Chapati	Fair
9.4	Size	Medium	15.2	Bread	Fair
9.5	Shape	Parallel	<b>16.</b>	<b>Resistance to</b>	
9.6	Density	Dense	16.1	Lodging	Resistant
9.7	Awnedness	Awned	16.2	Shattering	Resistant
9.8	Supernumerary spikelet's	Absent	16.3	Diseases	
9.9	Speltoides	Absent	16.3.1	Stem rust	Resistant
9.10	Shattering	Resistant	16.3.2	Leaf rust	Resistant
9.11	Kink/twist	Absent	16.3.3	Stripe rust	Resistant
<b>10.</b>	<b>Awns at maturity</b>		16.3.4	Stem rust	Resistant
10.1	Distribution	Whole			

considered the founder of the green revolution. Up till now, it has released more than 60 high-yielding varieties of wheat for general cultivation in the province of Punjab as well as in Pakistan. But D-21 is the first variety of durum which is particularly developed for pasta production in Pakistan as it contains better quality traits from the industrial point of view. It was concluded from the current research that the newly developed durum variety D-21 has superior quality traits for pasta production,

high yielding, resistance to leaf and yellow rust, and gave a good performance in multi-location of Punjab as well as Pakistan.

## 5. ACKNOWLEDGMENTS

Wheat Research Institute Faisalabad is highly thankful to "CIMMYT" for the provision of basic breeding material to strengthen the durum wheat breeding program at WRI, Faisalabad. Moreover, Wheat Research Institute



**Durum-21:** Field view at heading stage



**Durum-21**



**Durum-21:** Spikes with grains



**Durum-21:** Spike

**Fig. 1.** Pictorial view of Durum-21 (Plant, grains, and spike)



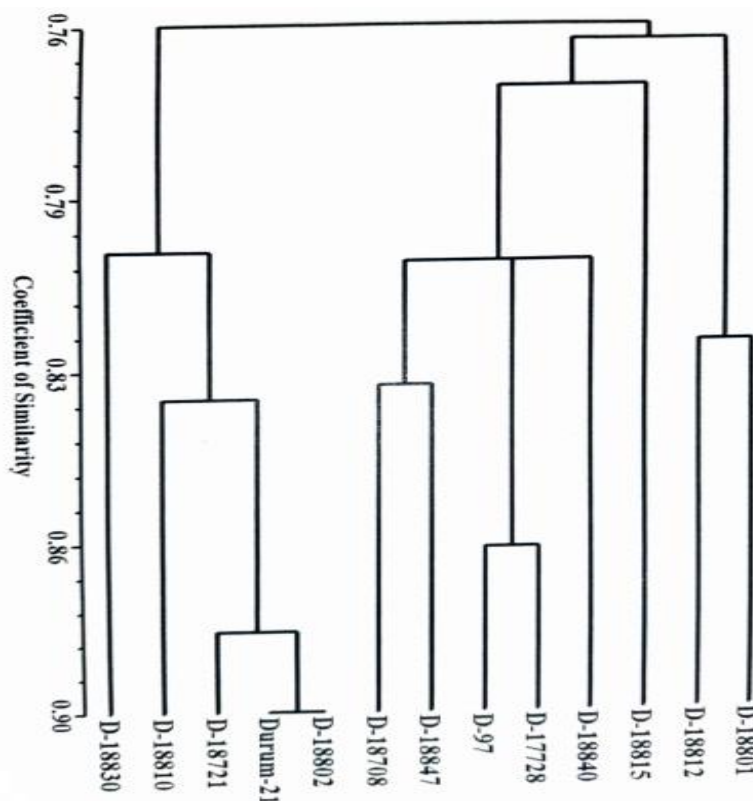


Fig. 2. Dendrogram of different Durum on the basis of similarity

Faisalabad acknowledges the “PARB” for the provision of funds for the development of the newly released variety “D-21”.

## 6. CONFLICT OF INTEREST

All the authors declared no conflict of interest.

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