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Morphological Diversity and Genetic Variation in a Global Collection of Durum Wheat under Pakistani Conditions

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Abstract

Durum wheat (Triticum durum Desf.) is widely grown for products such as pasta and macaroni, yet studies on its genetic variability under Pakistani conditions remain limited. This study aimed to evaluate the genetic diversity of 175 durum wheat accessions collected worldwide and grown for two consecutive years at Garhi Doppata, Azad Kashmir. Morphological traits recorded included germination, plant height, spike length, tillering capacity, peduncle length, leaf angle, seed number, spikelet number, plant thickness, yield attributes, and maturity stages. Analysis of variance revealed highly significant differences among genotypes for all characters studied, indicating substantial genetic variation. Correlation analysis demonstrated both positive and negative associations among yield-related traits, such as a positive relationship between plant height and heading date, and a negative relationship between seed number per spike and harvest index. The presence of wide morphological variation suggests the potential of this germplasm for improving yield, early maturity, and related agronomic traits. The study concludes that the evaluated accessions can serve as valuable genetic resources for durum wheat breeding programs in Pakistan, offering scope to combine high-yielding and adaptability traits into improved genotypes.

Keywords: Lima bean, Dof, genome-wide analysis, evolutionary analysis, transcription factor

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Introduction

Wheat is one of the world's major food crops. Taxonomically, wheat is placed in the family Gramineae, Genus *Triticum* L. (Laugerotte et al., 2022; Kerby and Kuspira, 1987; Cope, 1982). Cytologically, there are 3 main classes of wheat, viz, diploid (2n=2x=14), tetraploid (2n=4x=28) and hexaploid (2n=6x-42). Durum wheat (*Triticum durum* Desf.) is a tetraploid species with 2n=4x=28 chromosomes, genomically assigned to two different genomes A and B. The donor species of the A genome is likely to be *Triticum urartu* (Dvorak *et al*., 1993). The donor species of the B genome is not yet known with certainty. It is generally believed that the B genome was probably donated by a diploid species of the genus *Triticum* (Syn. *Aegilops*) (Fernandez-Calvin and Orellana, 1994).

In Pakistan, the market of durum wheat is expanding exponentially with the change in lifestyle, which is demanding organized basic research for proper utilization of existing genetic diversity in accordance with the material needs. In Pakistan, very few basic studies (for example, Saleemi *et al*., 1982) have been conducted on agronomy/breeding of durum wheat, but there has been no published work on genetic diversity in durum wheat using a large number of morphological characters. Present research is the first reported research to characterize the morphological variability of a global collection of durum wheat.

To determine genetic diversity and trait associations under local conditions in Azad Kashmir.

To identify accessions with desirable traits for use in breeding programs.

Materials and Methods

A world collection of durum wheat comprising 175 accessions was obtained from the Plant Genetic Resource Institute, National Agricultural Research Centre, Islamabad, Pakistan. The origin of the accessions was Pakistan, Syria, Egypt and Cyprus. Sowing of the accessions was done in accordance with the Randomized Complete Block Design with 3 replications. Plot size was 1 row of 1 meter length, with row to spacing 25 cm and plant to plant spacing within row, was 10 cm. Recommended agricultural practices were carried out and was done when needed. All the entries were planted for 2 years at the Agricultural Research Station, Garhi Doppata, Muzafrabad, Azad Kashmir (Latitude/longitude: 34°22′12″N 73°28′14″E, Decimal coordinates, 34.3700 73.4708, Altitude, 739 m).

Data were recorded for morphological character viz; days taken to germinate, germination percentage, plant height, Spike length, number of tillers per plant, peduncle length, leaf angle, number of effective tillers per plant, number of seeds per spike, number of spikelets per spike, plant thickness, grain yield per plant, 1000 grain weight, grain weight per spike, harvest index, number of days to 50% heading, and number days to 90% maturity. Harvest index was calculated using the following formula: HI=Dry grain yield per plant / dry total biomass per plant. Leaf angle was measured using hand handheld protector. All the numerical data were recorded on 3 samples, and average values were calculated and used for analysis.

Results and Discussion

Mean values for days to germination, germination percentage, days to spike emergence, plant height, spike length, number of tillers per plant, peduncle length, leaf angle, number of seeds per spike, number of spikelets per spike, plant thickness, grain yield per square meter, 1000 grain weight, grain weight per spike, harvest index, number of days to 50% heading, number of effective tillers per plant and number of days to 90%maturity were for year 1 and year 2(in parenthesis) were 20.62 (20.47), 47.32 (43.87), 26.18 (47.39), 102.64 (101.54), 8.99 (9.42), 7.16 (6.81), 84.64 (83.62), 59.65 (60.21), 56.15 (55.36), 18.72 (18.46) 0.49 (0.49) 347.23 (312.27), 51.86(50.98) 2.83 (2.72) 30.14 (29.54), 154.44 (154.44) 6.69 (6.73) 180.87 (181.73), respectively.

Analysis of variance was carried out for all the morphological traits recorded for both years of data individually using the computer program Menitap version 13.1. Results of ANOVA are presented in Table 1. Highly significant differences were observed among the genotypes for all the characters studied.

Like any other crop species, the main breeding objective of durum wheat breeding programs is to develop high and stable yielding lines having other desirable characters (for example, early maturity, disease resistance and better end-use quality, etc) combined in one improved genotype (Grosse-Heilmann et al., 2024; Poehlman and Sleper, 1995; Gashaw *et al*., 2007). To achieve this objective, the presence of sufficient genetic differences in yield attributes is a prerequisite. Highly significant differences for the yield contributing characters found during the present study indicated that the germplasm used during the present research has enough genetic variability for the important morphological characters and can be used successfully for the improvement of durum wheat. Present results are in close agreement with Gashaw *et al*. (2007), who also reported highly significant differences for plant height, number of spikelets per spike, number of seeds per spike and number of tillers per plant in Ethiopian durum wheat germplasm.

Table 1. Results of ANOVAs for morphological characters for Year 1 and Year 2

First year planting Second year planting

Character	F and p-value		F and p-value	
Days to germination	735.82	0.000	18.69	0.000
Germination percentage	70.49	0.000	16.63	0.000
Spike emergence	30.03	0.000	59.81	0.000
Plant Height	27.53	0.000	17.03	0.000
Spike length	11.47	0.000	8.62	0.000
No of tillers per plant	93.47	0.000	61.19	0.000
Peduncle length	14.69	0.000	15.74	0.000
Leaf angle	10.14	0.000	11.98	0.000
Seed per spike	456.59	0.000	416.13	0.000
Plant thickness	33.55	0.000	35.33	0.000
Grain yield per square meter	28.41	0.000	23.78	0.000
1000 grain weight	38.63	0.000	104.46	0.000
Grain weight per spike	443.61	0.000	343.85	0.000
days to 50% heading	172.09	0.000	19.52	0.000
No of effective tillers per plant	115.07	0.000	66.70	0.000
Days to 90% maturity	46.82	0.000	23.12	0.000

Correlation coefficients were calculated for all the possible combinations using mean values over the two years. Correlation coefficients (r values) are presented in Table 3.4. Significant (at $p<0.05$) negative correlation was observed among days to germination - number of effective tillers per plant, germination percentage - number of tillers per plant, germination percentage - grain yield per square meter, germination percentage - number of days to 90%maturity, days to spike emergence - number of days to 50% heading, days to spike emergence - number of effective tillers per plant, days to spike emergence - number of days to 90%maturity, plant height - peduncle length, number of tillers per plant - grain yield per square meter, number of tillers per plant - number of effective tillers per plant, number of seeds per spike - number of spikelets per spike, number of seeds per spike - grain yield per square meter, number of seeds per spike -1000 grain weight, number of seeds per spike - grain weight per spike, number of seeds per spike - harvest index, number of spikelets per spike - grain yield per square meter, number of spikelets per spike -1000 grain weight, number of spikelets per spike - grain weight per spike, number of spikelets per spike - harvest index, grain yield per square meter -1000 grain weight, grain yield per square meter - grain weight per spike, grain yield per square meter - harvest index, grain yield per square meter - number of effective tillers per plant, grain yield per square meter - number of days to 90%maturity, grain weight per spike - harvest index, number of days to 50% heading - number of days to 90%maturity. Significant (at p<0.05) positive correlation was observed among days to germination - number of days to 50% heading, days to germination - number of days to 90%maturity, germination percentage - days to spike emergence, germination percentage - spike length, germination percentage - leaf angle, germination percentage - number of days to 50% heading, days to spike emergence - plant height, days to spike emergence - spike length, days to spike emergence - peduncle length, plant height - number of days to 50% heading, Spike length - number of days to 50% heading, peduncle length - number of days to 50% heading,

Table 2. Correlation coefficient matrix for 18 morphological characters recorded for durum wheat

Correlations (Spreadsheet1)
Marked correlations are significant at p < .05000
N=192 (Casewise deletion of missing data)

Variable	Var1	Var2	Var3	Var4	Var5	Var6	Var7	Var8	Var9	Var10	Var11	Var12	Var13	Var14	Var15	Var16	Var17	Var18
Var1	1.00	0.03	-0.13	0.05	0.02	0.14	0.05	0.01	0.09	0.09	0.10	0.10	-0.03	0.09	0.08	-0.17	0.14	-0.23
Var2	0.03	1.00	-0.15	-0.05	-0.16	0.18	-0.02	-0.18	-0.03	-0.03	0.09	0.58	0.05	-0.03	-0.04	-0.15	0.13	0.18
Var3	-0.13	-0.15	1.00	-0.27	-0.16	0.02	-0.23	0.05	-0.05	-0.05	-0.03	-0.11	0.02	-0.05	-0.07	0.98	0.15	0.19
Var4	0.05	-0.05	-0.27	1.00	0.11	0.04	0.97	0.04	0.07	0.07	0.02	0.08	-0.06	0.07	0.11	-0.24	-0.00	-0.07
Var5	0.02	-0.16	-0.16	0.11	1.00	-0.07	-0.14	-0.03	-0.05	-0.05	0.08	-0.10	0.02	-0.05	-0.06	-0.15	-0.07	-0.06
Var6	0.14	0.18	0.02	0.04	-0.07	1.00	0.06	0.05	0.01	0.01	-0.01	0.59	-0.01	0.01	0.03	0.01	0.97	0.10
Var7	0.05	-0.02	-0.23	0.97	-0.14	0.06	1.00	0.05	0.09	0.09	-0.00	0.11	-0.06	0.09	0.13	-0.21	0.02	-0.05
Var8	0.01	-0.18	0.05	0.04	-0.03	0.05	0.05	1.00	0.06	0.06	0.07	-0.07	0.04	0.06	0.04	0.04	0.06	-0.10
Var9	0.09	-0.03	-0.05	0.07	-0.05	0.01	0.09	0.06	1.00	1.00	0.09	0.49	0.40	1.00	0.93	-0.04	0.01	0.07
Var10	0.09	-0.03	-0.05	0.07	-0.05	0.01	0.09	0.06	1.00	1.00	0.09	0.49	0.40	1.00	0.93	-0.04	0.01	0.07
Var11	0.10	0.09	-0.03	0.02	0.08	-0.01	-0.00	0.07	0.09	0.09	1.00	0.07	-0.02	0.09	0.10	-0.02	-0.04	0.12
Var12	0.10	0.58	-0.11	0.08	-0.10	0.59	0.11	-0.07	0.49	0.49	0.07	1.00	0.20	0.49	0.47	-0.12	0.53	0.18
Var13	-0.03	0.05	0.02	-0.06	0.02	-0.01	-0.06	0.04	0.40	0.40	-0.02	0.20	1.00	0.40	0.43	0.01	-0.00	0.03
Var14	0.09	-0.03	-0.05	0.07	-0.05	0.01	0.09	0.06	1.00	1.00	0.09	0.49	0.40	1.00	0.93	-0.04	0.01	0.07
Var15	0.08	-0.04	-0.07	0.11	-0.06	0.03	0.13	0.04	0.93	0.93	0.10	0.47	0.43	0.93	1.00	-0.07	0.01	0.09
Var16	-0.17	-0.15	0.98	-0.24	-0.15	0.01	-0.21	0.04	-0.04	-0.04	-0.02	-0.12	0.01	-0.04	-0.07	1.00	0.13	0.20
Var17	0.14	0.13	0.15	-0.00	-0.07	0.97	0.02	0.06	0.01	0.01	-0.04	0.53	-0.00	0.01	0.01	0.13	1.00	0.07
Var18	-0.23	0.18	0.19	-0.07	-0.06	0.10	-0.05	-0.10	0.07	0.07	0.12	0.18	0.03	0.07	0.09	0.20	0.07	1.00

Var 1,2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15. 16, 17 and 18 stand for days to germination, germination percentage, days to spike emergence, plant height, spike length, number of tillers per plant, peduncle length, leaf angle, number of seeds per spike, number of spikelets per spike, plant thickness, and grain yield per

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