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Assessment of genetic diversity studies for yield and yield contributing characters in durum wheat (*Triticum durum* Desf.) under limited irrigation condition

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Abstract
A field experiment was conducted with objective to study association of cause and effect relationship of yield contributing characters on yield. This study involves forty three genotypes of wheat evaluated at Agriculture Research Station, Niphad during *Rabi* 2018-19 in a Randomized Block Design with two replications. Wheat genotypes were evaluated for fourteen yield and yield contributing characters to study the genetic diversity among the genotypes using Mahalnobis D^2 statistic. The analysis of data revealed the significant difference among the genotypes for all the characters. D^2 values between all possible pairs of forty three genotypes ranged from 52.41 to 408.04. Based on genetic distance (D^2 value), forty three genotypes were grouped into eleven clusters indicating wider genetic diversity in the germplasm collections of wheat from different geographical origin. Out of eleven clusters formed, cluster I was the largest with twenty two genotypes followed by cluster II with eight genotypes, cluster IV with five genotypes and clusters III,IV,VI, VI,VII, VIII,IX,X,XI were monogenotypic. The clustering pattern indicated the absence of relationship between genetic diversity and geographical origin of genotypes. Hence crosses should be made between these widely related genotypes located in intra and inter cluster distances, to get desirable extent of heterotic potential in order to increase the production and productivity of wheat under limited irrigation conditions.

Keywords: Genetic diversity, D^2 statistics, durum wheat, cluster

1. Introduction
Wheat is one of the important and widely consumed cereal crop of the world. Durum wheat (*Triticum durum* Desf.) belongs to genus *Triticum* tribe, Triticeae, family poaceae and subfamily pooideae. *Triticum durum* is the only tetraploid species of wheat with basic chromosome number x=7 and 2n=4x=28. It was developed by artificial selection from the domesticated emmer wheat strains formerly grown in central Europe around 7000 BC. Durum in Latin means hard and the species is hardest among wheat species. It's high protein gluten content as well as its strength make durum wheat good for special uses. Wheat is mainly grown under rainfed conditions and yield is often constrained by water and heat stresses that are common during the grain-filling period, which is due to the low and unpredictable seasonal rainfalls and high temperatures during the last stages of its development cycle. Terminal drought and heat stresses negatively affect wheat grain weight and yield. Lack of moisture near the soil surface commonly delays sowing, reducing grain yields of Australian wheat crops. Deep sowing would allow growers to make use of soil moisture lying below the drying topsoil, but the short coleoptiles of semidwarf wheats reduce emergence when sowing at depths greater than 5 cm. Selection of longer coleoptiles length helpful for fighting against moisture deficiency condition. Genetic diversity plays an important role in plant breeding either to exploit heterosis or to generate productive recombinants. The choice of parents is of paramount importance in breeding programme. Improvement in crop is based on selection of superior parents which generates superior traits to its progenies. More variation within species is useful for selection of parents. In the present investigation diverse genotypes of durum wheat were evaluated.

2. Material and Methods
The experiment was taken place at Agricultural Research Station, Niphad (District Nashik) during season Rabi 2018-2019 to identify the diverse genotype for limited water condition between forty one genotypes with two checks of Durum wheat. Randomized block design (RBD) was used for experiment with two replications in two rows of 6.00 meter length having spacing of 20 cm between the rows.

Experiment was started on 5 November 2018, planting was done by hand drilling. Recommended fertilizer rate was of 60:30:00 kg/ha (N:P:K). Observations were recorded by selecting 5 random plants from each genotype for 14 characters *viz*.; days to 50% heading, coleoptile length, days to maturity, plant height (cm), tiller per meter, peduncle length, flag leaf length (cm), flag leaf breadth (mm), spike length, number of spikelets, number of flower per spike, grains per spike, 1000 grains weight (g), and grain yield per running meter (q/ha). Statistical analysis was performed by methods proposed by Panse and Sukhatme (1985) [8]. The analysis of divergence was carried out by D^2 statistic of Mahalnobis (1936) [5] as described by Rao (1952) [9].

3. Results and Discussion

Cluster formation: The 43 genotypes of wheat under investigation were grouped into eleven clusters in which cluster I was with twenty two genotypes emerged as the largest cluster. Cluster II was with eight genotypes, cluster IV with five genotypes. The clusters III, IV, VI, VII, VIII, IX and X were solitary.

Intra and inter cluster distance: The intra and inter cluster D^2 and D values were worked out by D^2 statistics. The mean D^2 values of cluster elements were used as measures of intra and inter cluster distance. The maximum inter cluster distance was observed between cluster II and XI (408.04) followed by cluster II and VIII (302.76), cluster X and XI (277.55), cluster VIII and X (266.66) cluster II and III (238.39), cluster II and VII (231.64), cluster III and IX (223.20), cluster V and VIII (219.33). The maximum Intra cluster divergence among the eleven clusters revealed that cluster V had maximum intra cluster distance (79.03) followed by cluster II (58.67) and cluster I (56.25). The least intra cluster distance was observed for cluster IIIV, IV, VI, VII, VIII, IX, X and XI (D =0).

Cluster mean: Cluster means for fourteen characters are presented in table revealed a wide range of variability for most of the character. The mean values of cluster II (79.63 days) was early for days to 50 per cent heading while cluster XI (55.50 days) had late heading, cluster XI (99.50 days) exhibited earliness by recording minimum days to maturity while, cluster II (119.56 days) exhibited lateness. cluster IV and VII (40.40 mm) recorded highest cluster mean for coleoptile length and cluster IX (33.45 mm) recorded lowest mean for coleoptile length, cluster VI (74.50) and cluster III (73.45) recorded highest and lowest cluster mean for plant height, respectively, also cluster IX (26.80) recorded highest number of tillers per running meter followed by cluster XI (24.80), cluster V (23.42) and least number of tillers per meter recorded in cluster VIII (14.40). Cluster VII (22.95) recorded longest mean peduncle length while shortest mean peduncle length recorded by cluster X (13.10). Highest and lowest mean values for flag leaf length was recorded by Cluster VII (24.00 cm) and cluster IV (14.40 cm). Cluster IX recorded highest cluster mean (1.65 cm) for flag leaf length while lowest recorded by cluster VI (1.20 cm).The clusters VII (17.65, 51.70 and 49.0) recorded highest mean values for spikelets per spike (17.65), flowers per spike (51.70) and grains per spike (49.0) while cluster VI (13.60, 36.50 and 33.80) recorded lowest mean values for the similar characters. Cluster III (59.60) recorded highest cluster mean for 1000 grain weight and lowest cluster mean for 1000 grain weight was recorded by cluster V (40.69). Cluster IX (65.55) recorded highest cluster mean for grain yield and lowest cluster mean was observed in cluster VI (31.40).

Inclusion of divergent parents in hybridization programme serves the purpose of combining desirable genes, so as to obtain desirable recombinants. Quantitative measurement of genetic diversity would be more useful in preliminary evaluation of genotypes under study. The summarized information on intra-cluster (diagonal) and inter cluster distances among eleven clusters is presented in the table which revealed that the intra- cluster distance value ranged from 0.00 to 79.03. While maximum inter cluster distance was observed between cluster II and XI (408.04). The minimum inter-cluster distance (52.41) was observed between cluster III and VIII, indicating close genetic association between the genotypes of these two clusters. The maximum Intra cluster divergence among the eleven clusters revealed that cluster V had maximum intra cluster distance (79.03) followed by cluster II (58.67) and cluster I (56.25). The least intra cluster distance was observed for cluster III, IV, VI, VII, VIII, IX, X, and XI (D=0). Considering the cluster means presented in table source clusters are formed and are presented in table. These source clusters provides desired parents for hybridization programmes for improvement in the characters shown against them are listed. Dotlacil *et al.* (2000) [1], Gashaw *et al.* (2007) [3], Hailegiorgis *et al.* (2011) [4], Singh *et al.* (2014) [10], Fikre *et al.* (2015) [2], Malviya *et al.* (2017) [6] and Mengistu *et al.* (2015) [7] also studied different accessions or germplasm for diversity and grouped them in different clusters concluding that geographical diversity is not similar as genetic diversity giving reason of mutual exchange of germplasm by research workers or crop breeders.

Table 1: Suggested parents for inclusion in hybridization programme

Cluster	Genotype	Characters to be improved
IX	AKDW 2997-16	Grain yield Productive tillers per meter
VII	NIDW 15	Coleoptile length Number of flowers grain / spike Spike length
III	NIDW 1470	1000 grain weight (g)
IV	NIDW 1479	Coleoptile length
XI	NIDW 1490	Earliness Days to maturity
X	NIDW 1458	Peduncle length
II	NIDW 1462	Coleoptile length & Productive tillers / meter

Table 1. Distribution of 43 genotypes of wheat in to different clusters

Cluster	Number of genotypes included	Genotypes
I	22	NIDW 1484, NIDW 1492, NIDW 1489, NIDW 1478, NIDW 1491, NIDW 1453, NIDW 1473, NIDW 1466, NIDW 1468, NIDW 1476, NIDW 1457, NIDW 1454, NIDW 1456, NIDW 1455, NIDW 1486, NIDW 1483, NIDW 1477, NIDW 1474, NIDW 1487, NIDW 1467, NIDW 1485, NIDW 1472
II	08	NIDW 1462, NIDW 1482, NIDW 1461, NIDW 1463, NIDW 1464, NIDW 1460, NIDW 1481, NIDW 1480
III	01	NIDW 1470
IV	01	NIDW 1479
V	05	NIDW 1465, NIDW 1475, NIDW 1459, NIDW 1488, NIDW 1452

VI	01	NIDW 1469
VII	01	NIDW 15
VIII	01	NIDW 1471
IX	01	AKDW 2997-16
X	01	NIDW 1458
XI	01	NIDW 1490

Table 2: Average intra (diagonal) and inter (above diagonal) cluster D and D^2 (in bracket) values of 11 cluster formed from 43 genotypes of wheat

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
I	7.50(56.25)	11.68(136.42)	10.62(112.78)	9.44(89.11)	9.26(85.74)	9.64(92.92)	10.34(106.50)	11.06(122.32)	9.15(83.72)	10.24(104.85)	11.80(139.24)
II		7.66(58.67)	15.44(238.39)	14.17(200.78)	12.23(149.57)	13.03(169.78)	15.22(231.64)	17.40(302.76)	11.25(126.56)	10.34(106.50)	20.20(408.04)
III			0.00(0.00)	10.65(113.42)	14.26(203.34)	7.28(52.99)	13.29(176.62)	7.24(52.41)	14.94(223.20)	14.46(209.09)	12.73(162.05)
IV				0.00(0.00)	9.66(93.31)	8.40(70.56)	13.89(192.93)	12.41(154.00)	12.83(164.60)	12.57(158.00)	11.12(123.65)
V					8.89(79.03)	11.72(137.35)	13.50(182.25)	14.81(219.33)	11.41(130.18)	10.45(109.20)	13.74(188.78)
VI						0.00(0.00)	14.50(210.25)	11.69(136.65)	13.04(170.04)	9.24(85.37)	13.45(180.90)
VII							0.00(0.00)	9.66(93.31)	9.76(95.25)	14.60(213.16)	12.44(154.75)
VIII								0.00(0.00)	14.23(202.49)	16.33(266.66)	10.73(115.13)
IX									0.00(0.00)	10.06(101.20)	13.90(193.21)
X										0.00(0.00)	16.66(277.55)
XI											0.00(0.00)

Table 3: Mean performance of cluster for 14 characters in 43 wheat genotypes

Character Cluster	Days to 50% Heading	Days to maturity	Coleoptile length (cm)	Plant height (cm)	Number of productive tillers/meter	Peduncle length (cm)	Flag leaf length (cm)	Flag leaf breadth (cm)	Spike length (cm)	Number of spike-lets / spike	Number of flowers / spike	Number of grains / spike	Thousand grain weight (g)	Grain yield per running meter (g)
I	68.05	111.18	36.43	72.57	22.54	15.68	20.15	1.46	6.03	15.18	42.46	40.17	50.03	44.78
II	79.63	119.56	35.19	71.63	21.02	13.45	18.90	1.50	6.23	15.18	42.39	39.67	44.28	36.56
III	64.50	107.50	38.15	73.45	16.15	14.15	15.50	1.25	5.90	13.75	37.25	35.35	59.60	33.90
IV	62.00	106.00	40.40	66.75	19.65	16.60	14.40	1.50	5.90	14.95	41.35	39.45	45.40	35.15
V	67.20	110.40	36.35	73.13	23.42	15.60	20.87	1.45	5.90	15.51	42.13	39.44	40.69	38.20
VI	65.00	109.00	37.05	74.50	15.75	14.00	15.70	1.20	5.70	13.60	36.50	33.80	53.10	31.40
VII	69.00	112.50	40.40	64.25	18.65	22.95	24.00	1.45	7.35	17.65	51.70	49.00	52.10	47.50
VIII	63.00	108.00	38.05	69.30	14.40	14.90	19.45	1.35	7.05	16.70	47.50	45.30	59.20	38.65
IX	73.00	115.50	33.45	67.00	26.80	16.15	22.30	1.65	6.95	16.20	46.80	45.40	54.00	65.55
X	70.00	116.50	34.95	73.90	19.15	13.10	21.90	1.55	6.15	15.00	38.80	36.15	47.00	38.80
XI	55.50	99.50	35.25	69.90	24.80	18.15	21.60	1.50	6.00	14.60	42.35	40.55	56.95	57.05

Table 4: Per cent contribution of 11 characters for divergence in wheat

Sr. No.	Characters	Number of times appeared 1st in ranking	Per cent contribution
1.	Days to 50% heading	275	30.45
2.	Days to maturity	4	0.44
3.	Coleoptile length (mm)	3	0.33
4.	Plant height (cm)	5	0.55
5.	Tiller /meter	106	11.74
6.	Peduncle length (cm)	8	0.89
7.	Flag leaf length (cm)	69	7.64
8.	Flag leaf breadth (cm)	3	0.33
9.	Spike length (cm)	2	0.22
10.	Spikelet per spike	13	1.44
11.	Flower per spike	50	5.54
12.	Grains per spike	25	2.77
13.	1000 grain weight (gm)	281	31.12
14.	Grain yield	59	6.53
Total			100.00

4. Conclusion

Three characters *viz*., thousand grain weight (31.12%), Days to heading (30.45%) and Tillers per meter (11.74%) contributed more than 73% of total diversity. Keeping in view all the above aspects, the genotypes *viz*., AKDW 2997-16, NIDW 15, NIDW 1470, NIDW 1479, NIDW 1490, NIDW 1458 and NIDW 1462 in the present studies, deserve to be considered as potent parents for future crossing programme for improvement in grain yield.

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