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GENETIC DIVERSITY AND ASSOCIATION STUDIES FOR GRAIN YIELD AND ITS ATTRIBUTING TRAITS IN TETRAPLOID WHEAT (*T. TURGIDUM* SUBSPS. DURUM)

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ABSTRACT
The present study was carried out during *Rabi* 2015-16 on 94 durum wheat genotypes including three checks, namely, HI8498, PDW 291 and PDW 233 grown at the Research Farm of Deptt. of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar. Positive and significant correlation was observed for tiller number per meter and grains per spike with grain yield per plot. Plant height and days to heading had negative and significant correlation with grain yield per plot. Plant height, days to maturity, tiller number per meter, grains per spike had positive direct effect on grain yield. Spike length, days to heading and 1000-grain weight had negative direct effect on grain yield per plot. Based on Euclidean cluster analysis 94 durum genotypes were grouped into 8 distinct clusters. Cluster VI was the biggest with 19 genotypes while cluster II was the smallest with 3 genotypes only. Cluster II, V and VI had genotypes with highest cluster mean values for traits- tiller number per meter and 1000-grain weight. Present study suggests that selection of these traits could be effective in improving yield potential of durum wheat. Selection of diverse parents for purposeful hybridization will lead to the achievement of a breeding goal.

INTRODUCTION

Durum wheat also known as macaroni wheat or pasta wheat (*T. turgidum* subsps. *durum*) is the only tetraploid wheat species that is widely cultivated today and has commercial importance. Durum wheat is the second most important wheat sps. in the international and national food grain market. Durum cultivation covers 10-11% of world wheat areas and accounts about 8% of the total wheat production (Ganeva *et al*., 2011). Globally it covers about 20 million hectare area with a production of 30 million ton (Kahrizi *et al*., 2010). In India, its production accounts to roughly 2.5 million ton and mostly consumed in the domestic market itself (Sethi, 2016). With the exploding population, expanding urbanization and rising incomes, the dietary preferences like consumption of more processed foods is increased among people (FAO, 2012). Hence its importance in processing industries demands enough variability and diversity for yield and attributing traits.

As yield is a quantitatively inherited character, environment has marked effect on it. So, direct selection for yield could be misleading. The study of genetic variability, correlation and direct and indirect effects of yield components provides a way for fulfillment of breeding objective (Chaudhary *et al*., 1986). Furthermore, selections on the basis of simple correlations alone cannot present optimal results. Therefore, it is essential to determine direct and indirect effect of traits on grain yield (Dewey and Lu 1959).For a meaningful breeding programme, information about the genetic makeup of morphological traits that are important in enhancing the target traits helps in making important decisions about the proper choice of parents for incorporation in hybridization programme.

A number of studies have been done for knowing relationship between grain yield and associated traits in durum wheat. Kahrizi *et al.,* 2010 studied eighteen durum wheats to estimate genetic variability parameters and relationship among 11 agro-physiological traits. They reported significant association among genotypes for the characteristics like plant height, number of tillers per plant, peduncle length, flag leaf, spike height, leaf area index and net assimilation rate. Cifci (2012) estimated heterosis, correlation and path analysis for grain yield per spike and component characteristics in durum wheat (*Triticum durum* desf). Tsegaye *et al.,* 2012 also estimated genetic variability, correlation and path analysis in durum wheat germplasm (*Triticum durum* Desf). Yadawad *et al.,* 2015 studied genetic variability for yield parameters and rust resistance in F_2 population of wheat (*Triticum aestivum* L.). Asha *et al*. (2015), Sahu and Verulkar (2015) and Kalpande (2015) also carried out similar kind of studies in okra, rice and French bean respecetively for improvement of yield potential of respective species. Genetic diversity studies offers prospects for improvement of individual plant traits. Genetic divergence analysis estimates the extent of diversity present among the studied genotypes (Gupta *et al.,* 2010). These studies could help the plant breeder in selecting the diverse parents for purposeful hybridization (Baenziger and Depauw, 2009).

Keeping in view the above facts, the present investigation was undertaken with the objective to estimate the correlation coefficient and path analysis for yield and attributing traits and genetic diversity in 94 promising genotypes of durum wheat based on 8 important traits, in order to, help the plant breeder in selecting promising and genetically diverse genotypes for incorporation in hybridizing programme so that the success of the breeding goal could be achieved.

MATERIALS AND METHODS

In order to evaluate phenological traits of durum wheat genotypes by correlation and path analysis, the present study was carried out on 94 promising exotic genotypes of durum wheat including three checks *viz*. HI8498, PDW 291 and PDW 233. These genotypes were sown in November during *Rabi* 2015-16 in paired rows using Complete Augmented Block Design with a net plot size of 2.5m x 0.4m with 25 cm row to row distance and 15 cm plant to plant distance at Research farm of Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar situated at a latitude of 29º10′N, longitude of 75º46′E and altitude of 215.2 m above sea level in semi-tropical region of North Western Plain Zone of India. Observations were recorded on five randomly chosen plants of each genotypes in each row for eight metric traits namely plant height (cm), days to heading, days to maturity, tiller no. per meter, grains per ear, spike length (cm), 1000-grain weight (g), and grain yield per plot (g).

Correlation coefficient and path coefficient analysis for grain yield was worked out by method suggested by Al-Jibouri *et al.* (1958) and Dewey and Lu (1959) respectively. Euclidean cluster analyses (Spark, 1973) have been applied to assess genetic diversity and grouping of genotypes was done on the basis of minimum genetic distance using Wards (1963) minimum method.

Statistical Analysis: In the present study, the direct and indirect effects of the traits were evaluated using correlation and path coefficient analyses and grouping of genotypes were done using INDOSTAT version 8.1 Statistical Software.

RESULTS AND DISCUSSION

Knowledge with respect to the association of various component traits with grain yield could be of immense help in designing an effective and efficient selection and screening programme.Correlation between grain yield and attributing traits for 94 durum wheat genotypes were presented in Table1

Plant height was positively and significantly associated with days to heading, spike length and 1000-grain weight while negative and significant association was recorded for tiller number per meter, grains per spike and grain yield per plot. Similar findings were also obtained by Khan *et al.,* 2013 for 1000-grain weight while estimation of correlation and path analysis of durum wheat *(Triticum turgidum* L. var. *Durum)*.Cifci (2012) recorded negative but non-significant association of plant height with spikelets per spike.

Days to heading showed positive and significant association with spike length and 1000-grain weight but negative and significant association with tiller number per meter, grains per spike and grain yield per plot. Akram *et al.,*2008 and Abinasa *et al.,* 2011 also reported positive and significant association of days to heading with grain yield per plot. No correlation was recorded between days to maturity, days to heading, tiller no. per meter, 1000-grain weight and grain yield per plot.

In the present study, tiller number per meter, grains per spike and grain yield per plot were found positively and significantly associated with each other. Grains per spike directly determine the yield potential of a genotype (Ahmad *et al.*, 2006). Similarly other workers (Soylu and Akgün (2003), Yücel *et al*. (2009)

Table 1: Correlation coefficient of eight characters in durum wheat genotypes

	Plant height (cm)	Days to heading	Days to maturity	Tiller no. per meter	Grains per spike	Spike length (cm)	1000-grain weight (g)	Grain yield per plot (g)
Plant height (cm)	1	0.862**	0.013	-0.472**	-0.840**	0.541**	0.570**	-0.720**
Days to heading		1	-0.002	-0.676**	-0.938**	0.675**	0.638**	-0.923**
Days to maturity			1	0.052	0.028	-0.226*	0.06	0.044
Tiller no. per meter				1	0.661**	-0.605**	-0.315**	0.769**
Grains per spike					1	-0.728**	-0.614**	0.930**
Spike length (cm)						1	0.401**	-0.743**
1000-grain weight (g)							1	-0.594**

Table 2 : Direct (diagonal) and indirect effects of different characters on grain yield in durum wheat

	Plant height(cm)	Days to heading	Days to maturity	Tiller no. per meter	Grains per spike	Spike length (cm)	1000-grain weight (g)	Correlation Grain yield per plot
Plant height (cm)	0.273	-0.423	0	-0.084	-0.428	-0.034	-0.024	-0.72
Days to heading	0.235	-0.49	0	-0.12	-0.478	-0.042	-0.027	-0.922
Days to maturity	0.003	0.001	0.004	0.009	0.014	0.014	-0.002	0.043
Tiller no. per meter	-0.129	0.331	0	0.178	0.337	0.038	0.013	0.768
Grains per spike	-0.229	0.46	0	0.117	0.51	0.046	0.026	0.93
Spike length (cm)	0.148	-0.331	-0.001	-0.107	-0.371	-0.063	-0.017	-0.742
1000-grain weight (g)	0.156	-0.313	0	-0.056	-0.313	-0.025	-0.042	-0.593

Table 3: Classification of different durum wheat genotypes into eight different clusters

Cluster No.	No. of Genotypes	Genotypes
Cluster I	18	1, 2, 20, 42, 11, 12, 21, 10, 22, 23, 35, 32, 61, 19, 27, 47, 60, 34
Cluster II	3	17, 52, 15
Cluster III	5	3, 6, 7, 9, 91
Cluster IV	19	24, 28, 5, 43, 50, 44, 25, 48, 59, 31, 45, 33, 63, 84, 46, 49, 62, 18, 71
Cluster V	13	8, 39, 37, 30, 16, 29, 38, 58, 40, 41, 93, 51, 94
Cluster VI	13	4, 83, 82, 85, 86, 75, 87, 81, 76, 74, 79, 72, 73
Cluster VII	14	13, 80, 14, 53, 57, 90, 89, 54, 66, 68, 92, 77, 78, 67
Cluster VIII	9	26, 65, 70, 36, 56, 64, 69, 88, 55

Table 4: Intra and inter-cluster distances

Cluster No.	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII
Cluster I	2.827	4.194	3.89	3.21	3.711	4.813	4.196	3.834
Cluster II		2.377	5.14	4.343	4.625	5.794	4.709	5.188
Cluster III			3.007	3.795	4.112	5.276	4.549	5.003
Cluster IV				2.589	3.639	4.056	3.683	3.499
Cluster V					3.275	5.384	4.222	4.241
Cluster VI						3.632	4.416	4.383
Cluster VII							3.232	3.82
Cluster VIII								2.895

Table 5: Cluster means values of durum wheat genotypes

Cluster No.	Plant height (cm)	Days to heading	Days to maturity	Tiller no. per meter	Grains per spike	Spike length (cm)	1000-grain weight (g)	Grain yield per plot
Cluster I	97.444	101.889	132.889	140.111	58	8.644	38.933	594.444
Cluster II	97.333	101.333	131.333	213.333	69	10.833	35.667	560
Cluster III	90.4	101.2	135.2	120.8	75.2	7.88	38.08	504
Cluster IV	93.053	101.632	130.368	118.737	64.211	8.621	40.363	446.053
Cluster V	95.385	101.308	130.462	160.538	68.846	7.608	36.562	677.692
Cluster VI	81.385	99.846	129.923	101.538	56.846	9.131	50.146	450.385
Cluster VII	94	99.571	129.929	111.429	70.929	9.221	46.236	682.143
Cluster VIII	101.556	99.556	129.222	116.889	56.444	8.3	46.544	538.889

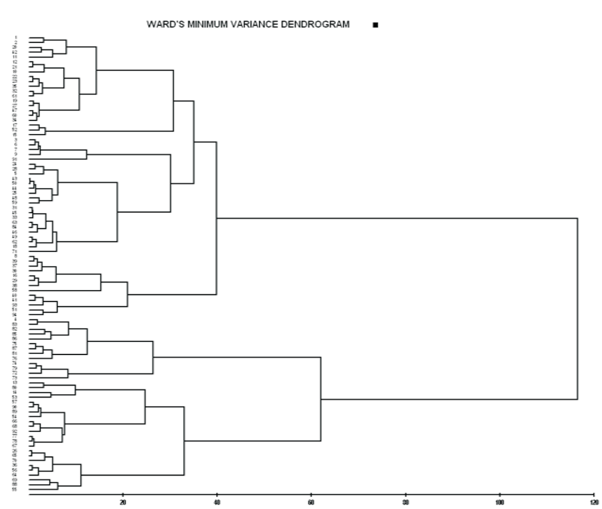

Figure 1: Dendrogram of 94 durum wheat genotypes based on Euclidean distance

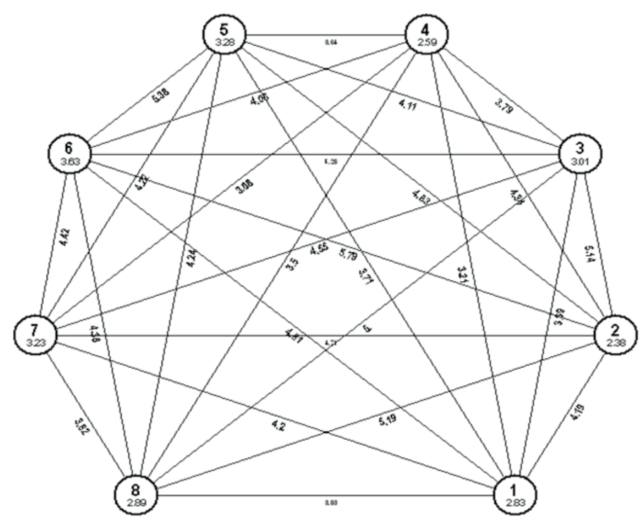
Figure 2 : Intra-inter Euclidean distance between 8 clusters of durum wheat genotypes

and Cifci (2012)) also reported positive and significant association between grain number per spike and grain yield per spike in durum wheat studies. Desheva (2016) reported similar interpretation in their study of correlation and path coefficient analysis in winter bread wheat varieties. Subhashchandra *et al.,* 2009 also reported similar results while assessing the genetic variability and relationship between genetic diversity and transgressive segregation in tetraploid wheat.

1000-grain weight was found negatively and significantly associated with grain yield per plot, tiller number per meter and grains per spike while positive and significant association was reported with, spike length. Similarly, Abinasa *et al.,* 2011 and Hama *et al.*, 2016 also found negative and significant association of 1000-grain weight with grains per spike in durum and bread wheat genotypes respectively. In contrast, Cifci 2012 reported no association between 1000-grain weight with grains per spike. Present study reported negative and significant association between spike length and grain yield per plot.

Path analysis partitions correlation coefficient into direct and indirect effects. In the present study, the response variable was grain yield and seven predictor variables were plant height, days to heading, days to maturity, tiller number per meter, spike length, grains per spike and 1000 grains weight. The residual factor value was found 0.06092 which indicate that there are some other factors influencing the grain yield which are not being included in this study.

Plant height showed positive direct effect on grain yield per plot and indirect effect via days to maturity. Similar observations were also reported by other workers (Aycicek and Yildrim, 2006 and Cifci 2012).

Days to heading showed negative direct effect while positive indirect effects via plant height on grain yield per plot.

Direct effect of days to maturity was positive on grain yield and indirect effect via plant height, days to heading, tiller number per meter, spike length and grains per ear was also positive. Indirect effect via 1000-grain weight was negative on grain yield per plot.

Tiller number per meter and grains per ear had positive direct effect on grain yield per plot and their indirect effects via days to heading, days to maturity, spike length and 1000-grain weight was also positive while via plant height, negative indirect effect was shown on grain yield per plot.Similiar results have been reported by Ayçiçek and Yýldýrým (2006). Ali *et al.* (2008), Subhashchandra *et al.* (2009) and Khan *et al.*, 2013 reported positive direct effect of tiller number per meter on grain yield. Dogan (2009) reported similar results for grains per ear and grain yield.

Spike length and 1000-grain weight showed negative direct effect. Mahmood *et al.* (2006) also reported negative direct effects of spike length on grain yield. Indirect effect of both characters via days to heading, tiller number per meter, grains per spike was also found negative. 1000-grain weight showed positive indirect effect via days to maturity while spike length showed negative indirect effect for the same.

Hence the author suggests the possibility of improving grain yield through direct selection of traits-tiller number per meter, grains per ear, days to maturity and plant height.Furthermore, it is undesirable to select the traits that exhibited negative direct effect on yield as these selections will not be beneficial.

Cluster analysis

Euclidean cluster analysis was employed and constellation of 94 durum wheat genotypes into different clusters was done following Ward's minimum variance method developed by Ward in 1963. These studies were important as the genetic diversity existing among the germplasm is important and useful in making better choice of parents for exploiting higher heterosis and obtaining transgressive segregants. Fufa *et al.,* 2005 empahsized importance of morphological traits for estimation of genetic diversity and cultivar development.

The analysis of genetic diversity of durum wheat genotypes through the cluster analysis based on Euclidean distance (Ward, 1963) showed considerable amount of genetic diversity in the material.On the basis of relative magnitude of distances, 94 durum wheat genotypes were grouped into 8 clusters in such a way that the genotypes within the cluster had more similarity than the genotypes belonging to different clusters (Fig 1).

Table 2 present classifications of 94durum wheat genotypes into eight distinct clusters. Out of the 8 clusters, cluster IV was the biggest cluster with 19 genotypes while cluster II was the smallest cluster with 3 genotypes only. Cluster I contains 18 genotypes. Cluster VII contain 14 genotypes while cluster V and VI contains 13 genotypes each. Cluster VIII contains 9 genotypes while cluster III contains small number of5 genotypes.

Cluster distances

In general intra-cluster distances were relatively lower than inter-cluster distances showing that genotypes included within a cluster were genetically closer to each other than the genotypes included in different clusters (Table 4). Cluster II had smallest intra-cluster distance (2.377) while cluster VI had largest intra-cluster distance (3.632). Maximum intra-cluster distance was shown by cluster VI (3.632) followed by cluster V (3.275) followed by cluster VII (3.232), cluster III (3.007), cluster VIII (2.895), cluster I (2.827), cluster IV (2.589) and cluster II (2.377).Among the 8 clusters, maximum inter-cluster distance was shown by cluster VI with three clusters namely; cluster II (5.794) followed by cluster V (5.384) and cluster III (5.276). This shows that genotypes in cluster VI were more divergent than other clusters. Minimum inter-cluster distances were shown by cluster IV with cluster I (3.210) and cluster VIII (3.499). This implies that cluster IV was less divergent.

For plant height, highest cluster mean value was shown by cluster VIII (101.556) while lowest cluster mean value was shown by cluster VI (81.385). Semi-dwarf varieties shows more yield potential as compared to tall varieties as lodging cause loss in yield potential of a crop species. So, in the present case, cluster VI was desirable. For heading and maturity days, cluster I and cluster III shows highest cluster mean values respectively while cluster VIII shows minimum cluster mean values for both the characteristics. Cluster II (213.333) followed by cluster V (160.538) showed highest cluster mean value for tiller number per meter. So, genotypes in cluster II as well as cluster V could be selected for use in hybridizing programme. For grains per spike, cluster III followed by cluster VII showed highest cluster mean values 75.200 and 70.929 respectively. Cluster mean values for spike length ranged from 7.608 (cluster V) to 10.833 (cluster II). Cluster VI contain genotypes with highest cluster mean value (50.146) for 1000-grain weight. Cluster VI was followed by cluster VIII (46.544) and cluster VII (46.236). So, for maximum 1000-grain weight, genotypes from these clusters could be chosen for use in particular breeding programme. Maximum cluster mean value for grain yield per plot was shown by cluster VII (682.143) followed by cluster V (677.692).

Overall, cluster V, VI and cluster II contains genotypes with appropriate combination of yield and its attributing traits.

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