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Correlation and path analysis for quantitative traits in durum wheat (*Triticum durum* L.)

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Abstract
Forty cultivars of durum wheat were evaluated for yield and yield contributing traits in randomized block design (RBD) with three replications to determine the association between yield and yield attributing traits through correlation and path analysis. Significant genotypic differences were observed for all the 12 quantitative traits studied, indicating presence of considerable amount of variation among genotypes. The correlation coefficient analysis showed significant and positive correlation of grain yield per plant with biological yield per plant, harvest index, number of productive tillers per plant, number of grains per main spike and grain weight per main spike. Significant and positive correlations were observed for number of productive tillers per plant with biological yield per plant; number of grains per main spike with grain weight per main spike and harvest index; grain weight per main spike with harvest index and 100-grain weight; harvest index with 100-grain weight. The genotypic path coefficient analysis revealed that the biological yield per plant and harvest index exhibited high and positive direct effects on grain yield per plant. Biological yield per plant, grain weight per main spike, number of grains per main spike, number of productive tillers per plant and harvest index merits special attention in formulating selection strategy in durum wheat for developing high yielding varieties.

Keywords: Genetic variability, correlation, direct and indirect effects, path analysis, *Triticum durum*.

Introduction

Wheat (*Triticum spp*.) is accorded a premier place among the cereals because of the vast acreage devoted to its cultivation, its high nutritive value and its association with some of the earliest and most important civilization of the world. Three species of wheat viz., *Triticum aestivum* (bread wheat), *Triticum durum* (macaroni wheat) and *Triticum dicoccum* (emmer wheat) are presently grown as commercial crop in India. For commercial production and human consumption, durum wheat is the second most important *Triticum* species, next to common wheat (*Triticum aestivum*). Tetraploid wheat has been under cultivation in Ethiopia since ancient times. Among the tetraploid, durum wheat (*Triticum turgidum* L. var. *durum*) is the predominant species. Durum wheat (*Triticum durum*) is a monocotyledonous plant of the Poaceae family. It is the only tetraploid (AABB, 2n=4x=28) species of wheat which has commercially a great importance and carries raw material of numerous foods such as macaroni and semolina in alimentation of world population and is a promising and viable alternative crop for farmers (Shewry, 2009) [15]. It is cultivated on 10 to 11 per cent of the world wheat areas and accounting about 8 per cent of the total wheat production (Ganeva *et al*., 2010) [7]. The average world productivity of durum wheat is 25 quintals per hectare (CSA, 2011) [4]. The nutritional composition indicated that 100 g of durum wheat provides 339 calories and it consisted carbohydrate 71 g, protein 14 g, fat 2.5 g, minerals 2 g and considerable proportions of vitamins (thiamine and vitamin-B) and minerals like zinc and iron (Wolde *et al*., 2016) [17].
Different components of grain yield often exhibit varying degree of association with grain yield as well as among themselves. Character association studies provide better understanding of yield components which helps the plant breeders to improve yield through indirect selection for highly heritable traits which are associated with grain yield. Correlation and path analysis could be used as an important tool to bring information about appropriate cause and effects relationship between grain yield and some yield components (Khan *et al*., 2003) [10]. Path coefficient analysis developed by Wright (1921) [18] could provide a more realistic picture of the relationship, as it partitions the correlation coefficient into direct and indirect effects of the variables.

Path coefficient analysis provides means to quantify the interrelationship of different yield components and indicate whether the influence is directly reflected in the yield or take some other path ways to produce an effect. Therefore, the present experiment was planned to study character association and path analysis which provide the information of yield contributing characters and a breeder can practice selection using this information for the isolation of superior accessions from gene bank.

Materials and Methods

The experimental material consisted of 40 diverse genotypes of wheat (*Triticum durum*) representing different geographic origin were sown in a randomized block design with three replications at Wheat Research Station, Junagadh Agricultural University, Junagadh. Each line was sown in a single row plot of 3.0 m length with a spacing of 22.5 cm × 10 cm. The genotypes were randomly allotted to the plots in each replication. All the recommended agronomical practices along with necessary plant protection measures were followed timely for the successful raising of the crop. Five competitive plants per genotype in each replication were randomly selected for recording observations on different characters *viz*., days to 50% flowering, days to maturity, grain filling period (Days), plant height (cm), number of productive tillers per plant, ear Length (cm), number of grains per main spike, grain weight per main spike (g), grain yield per plant (g), biological yield per plant (g), harvest index (HI) (%), 100-grain weight (g) and replication-wise mean values of five randomly selected plants in each entry were used for the statistical analysis.

The genotypic correlation coefficient provides a measure of genotypic association between different characters, while phenotypic correlation includes both genotypic as well as environmental influences. The phenotypic and genotypic correlation coefficients for all the pair of characters were worked out as per Al-Jibouri *et al.* (1958) [1]. The data were subjected to covariance analysis from which different components of mean sum of products were estimated. The significance of the correlation values at (n-2) degrees of freedom was tested by adopting the formula suggested by Panse and Sukhatme (1967) [14]. The path coefficient analysis was carried-out as per the method suggested by Dewey and Lu (1959) [5].

Results and Discussion

In the present investigation, grain yield per plant had significant and positive correlation with biological yield per plant, harvest index, number of productive tillers per plant, number of grains per main spike and grain weight per main spike at both the genotypic and phenotypic levels indicating that these attributes had strong and desirable relationship with grain yield in durum wheat and therefore, were important for bringing genetic improvement in grain yield. The positive genotypic association has been reported between grain yield per plant and biological yield per plant (Fellahi *et al*., 2013; Mecha *et al*., 2017 and Ayer *et al*., 2017) [6, 11, 2]; grain weight per main spike (Nukasani *et al.*, 2013 and Ayer *et al*., 2017) [13, 2]; harvest index (Bergale *et al*., 2002; Mecha *et al*., 2017 and Ayer *et al*., 2017) [3, 11, 2]; number of productive tillers per plant (Mecha *et al*., 2017) [11]; and number of grain per main spike (Iftikhar *et al.*, 2012 and Ghafoor *et al.*, 2013) [9, 8].

The days to 50% flowering had significant and positive association with days to maturity at genotypic and phenotypic levels and it is an important component in identifying and deciding the duration of the wheat crop. Similar relationship has been reported by Mecha *et al*. (2017) [11]. Number of productive tillers per plant also exhibited significant and positive relationship with biological yield per plant at genotypic and phenotypic levels. Similarly, number of grains per spike also had significant and positive association with grain weight per main spike, harvest index and biological yield per plant at genotypic and phenotypic levels. Similar relationship has been reported earlier by Narwal *et al*. (1999) [12] and Sidharthan and Malik (2006) [16].

The genotypic path coefficient analysis revealed that the biological yield per plant and harvest index exhibited high and positive direct effects on grain yield per plant. Similar result has been reported by Mecha *et al*. (2017) [11]. Both these traits turned out to be major components of grain yield for direct selection. The residual effect was of low magnitude suggesting that the majority of the yield attributes have been included in the path analysis. In the present research, biological yield per plant and harvest index had highly significant and positive correlation with grain yield per plant and the direct effects of both components were also positive and highest. This suggested that there were little or no indirect effects of these traits on grain yield and whatever relationship existed with grain yield was direct. It was apparent from the genotypic path analysis that higher direct effects as well as appreciable indirect influences were exerted by biological yield per plant, harvest index, number of productive tillers per plant, grain weight per main spike, number of grains per main spike, 100-grain weight, days to 50% flowering and days to maturity towards grain yield per plant. Among these characters, biological yield per plant, grain weight per main spike, number of grains per main spike, number of productive tillers per plant and harvest index exhibited significant and positive association with grain yield per plant and hence, these traits may be considered as most important yield contributing characters and due emphasis should be placed on these components while breeding for high grain yield in durum wheat.

Table 1: Estimates of genotypic (rg) and phenotypic (rp) correlation coefficients among 12 characters in durum wheat

Characters		Days to 50% flowering	Days to maturity	Grain filling period (days)	Plant height (cm)	No. of productive tillers per plant	Ear length (cm)	No. of grains per main spike	Grain weight per main spike (g)	Biological yield per plant (g)	Harvest index (%)	100-grain weight (g)
Grain yield per plant (g)	r_g	-0.1618	-0.1400	0.1893	-0.1258	0.7261**	0.0619	0.6388**	0.6287**	0.8750**	0.7672**	0.2841
	r_p	-0.1460	-0.1057	0.1638	-0.1005	0.7070**	0.0844	0.6378**	0.6305**	0.8373**	0.7470**	0.2951
Days to 50% flowering	r_g		0.9282**	-0.8070**	0.2308	0.2125	0.3236*	-0.0925	-0.6704**	-0.0035	-0.3923*	-0.8065**
	r_p		0.9124**	-0.7804**	0.2257	0.2077	0.3025	-0.0713	-0.5403**	0.0004	-0.3260*	-0.7382**
Days to maturity	r_g			-0.6715**	0.2663	0.1805	0.2401	-0.0728	-0.6317**	0.0161	-0.3609*	-0.7366**
	r_p			-0.6231**	0.2593	0.1763	0.2249	-0.0177	-0.4667**	0.0220	-0.2660	-0.6566**
Grain filling period (days)	r_g				-0.1753	-0.1647	-0.3614*	0.1530	0.6114**	0.0974	0.2995	0.6451**
	r_p				-0.1635	-0.1625	-0.3231*	0.1192	0.4859**	0.0754	0.2470	0.5868**

Plant height (cm)	r_g r_p					-0.2440 -0.2274	0.1035 0.1031	-0.0719 -0.0451	-0.1685 -0.1105	-0.1880 -0.1584	-0.0618 -0.0433	-0.0307 -0.0218
No. of productive tillers per plant	r_g r_p						0.1054 0.1070	0.1700 0.1609	0.0065 0.0198	0.8396** 0.8176**	0.2876 0.2650	-0.2071 -0.1725
Ear length (cm)	r_g r_p							0.2570 0.2515	0.0460 0.0709	0.0750 0.0586	0.0286 0.0819	-0.2364 -0.2118
No. of grains per main spike	r_g r_p								0.7304** 0.7685**	0.4217** 0.3842*	0.7045** 0.6893**	0.1612 0.1562
Grain weight per main spike (g)	r_g r_p									0.2905 0.2694	0.8514** 0.8217**	0.7647** 0.6866**
Biological yield per plant (g)	r_g r_p										0.3610* 0.2814	0.0008 0.0202
Harvest index (%)	r_g r_p											0.5334** 0.5066**

*,** Significant at 5% and 1% levels, respectively.

Table 2: Genotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on grain yield per plant in durum wheat

Characters	Days to 50% flowering	Days to maturity	Grain filling period (days)	Plant height (cm)	No. of productive tillers per plant	Ear length (cm)	No. of grains per main spike	Grain weight per main spike (g)	Biological yield per plant (g)	Harvest index (%)	100-grain weight (g)	Genotypic correlation with grain yield per plant
Days to 50% flowering	0.2682	-0.0758	-0.0161	-0.0019	-0.0292	-0.0044	0.0103	-0.0041	-0.0029	-0.2403	-0.0657	-0.1618
Days to Maturity	0.2490	-0.0816	-0.0134	-0.0022	-0.0248	-0.0033	0.0081	-0.0039	0.0131	-0.2210	-0.0600	-0.1400
Grain filling period (days)	-0.2164	0.0548	0.0200	0.0014	0.0227	0.0049	-0.0171	0.0037	0.0793	0.1834	0.0525	0.1893
Plant height (cm)	0.0619	-0.0217	-0.0035	-0.0081	0.0336	-0.0014	0.0080	-0.0010	-0.1531	-0.0379	-0.0025	-0.1258
No. of productive tillers per plant	0.0570	-0.0147	-0.0033	0.0020	-0.1376	-0.0014	-0.0190	0.0000	0.6838	0.1762	-0.0169	0.7261**
Ear length (cm)	0.0868	-0.0196	-0.0072	-0.0008	-0.0145	-0.0137	-0.0287	0.0003	0.0611	0.0175	-0.0192	0.0619
No. of grains per main spike	-0.0248	0.0059	0.0031	0.0006	-0.0234	-0.0035	-0.1116	0.0045	0.3435	0.4315	0.0131	0.6388**
Grain weight per main spike (g)	-0.1798	0.0516	0.0122	0.0014	-0.0009	-0.0006	-0.0815	0.0061	0.2366	0.5215	0.0623	0.6287**
Biological yield per plant (g)	-0.0009	-0.0013	0.0019	0.0015	-0.1155	-0.0010	-0.0471	0.0018	0.8145	0.2211	0.0001	0.8750**
Harvest index (%)	-0.1052	0.0295	0.0060	0.0005	-0.0396	-0.0004	-0.0786	0.0052	0.2940	0.6125	0.0434	0.7672**
100-grain weight (g)	-0.2163	0.0601	0.0129	0.0002	0.0285	0.0032	-0.0180	0.0047	0.0006	0.3267	0.0814	0.2841

*,** Significant at 5% and 1% levels, respectively.

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