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Research Article

GENETIC VARIABILITY AND ASSOCIATION FOR QUALITY TRAITS IN ETHIOPIAN DURUM WHEAT (*TRITICUM TURGIDUM* L. VAR. *DURUM*) GENOTYPES AT HERA LIPHITU, SOUTHERN ETHIOPIA

[1,*]Yonas Shimelis, [2]Wassu Mohammed and [3]Tesfaye Letta

[1]Yabello Pastoral and Dryland Agricultural Research Centre, Oromia Agricultural Research Institute, Yabello, Ethiopia
[2]College of Agriculture and Environmental Sciences, Haramaya University, Haramaya, Ethiopia
[3]Technology Multiplication and Center Development, Oromia Agricultural Research Institute, Addis Ababa, Ethiopia

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ABSTRACT

Testing genotypes for the presence of variations and generation of genetic information is the first step in plant breeding to develop varieties for the targeted area of production. Therefore, this research was conducted at Hera Liphitu, Yabello Pastoral and Dryland Agriculture Research Center on farm research site, southern Ethiopia, with the objectives of estimating genetic variability and heritability of quality traits in Ethiopian durum wheat genotypes. A total of 21 durum wheat genotypes including seven released varieties and one local cultivar were evaluated using randomized complete block design with three replications. Analysis of variance revealed the presence of highly significant ($P \leq 0.01$) variation among genotypes for vitresneous, gluten content, zeleny index, wet gluten content, dry gluten content and test weight. The calculated values for heritability and genetic advance as percent of mean ranged from 4.13 (sodium dodecyl sulfate sedimentation test) and 78.96% (vitresneous) and 0.38 (ash content) and 20.95% (vitresneous), respectively. Correlation of zeleny index and gluten content, zeleny index and protein content, zeleny index and vitresneous were highly significant both at phenotypic and genotypic levels. Generally, it has been observed the presence of variability among the genotypes studied and the possibility of increasing grain yield by 10% by exerting 5% selection intensity that can be exploited to improve yield in the study area.

INTRODUCTION

Durum wheat (*Triticum turgidum* ssp. *durum*) is a monocotyledonous plant of the *Gramineae* family and of the Triticeae tribe and belongs to the genus *Triticum* (Clarke *et al*., 2002). It is a tetraploid (x = 7 and 4x = 2n = 28) with AABB genomes. Durum wheat is an economically important cereal crop grown throughout the world, although not as extensively as bread wheat. Durum is grown on approximately 17 million hectares worldwide, with production averaging 35.4 million metric tons. The major durum producing countries are the European Union (Italy, Spain, France, and Portugal), Canada, Syria, United State of America, and North Africa (CFIA, 2013). Quality is an important aspect of durum wheat. High quality pasta begins with good quality wheat.

****Corresponding author: Yonas Shimelis,***
Yabello Pastoral and Dryland Agricultural Research Centre, Oromia Agricultural Research Institute Yabello, Ethiopia.

Durum wheat is the best wheat for superior pasta products due to its kernel hardness, vitreous endosperm and golden amber color which also vary among durum wheat genotypes. Cooked pasta made from durum wheat semolina retains good firmness and elasticity and is resistance to surface disintegration and stickiness (Motalebi *et al*., 2007). Pasta is delicious and healthy food as ready source of protein and complex carbohydrates. The basic valid pasta quality today include a high yield of highly refined semolina; high protein, yellow pigment content and strong gluten for good pasta cooking quality. Protein content and type in the grain of durum wheat is important not only for pasta making, it is important also for human nutrition and end use processes quality. In addition, high protein determines premium prices for wheat in many regions of the world, making high grain protein content a primary target for durum wheat breeding programs (Olmos *et al*., 2003). Ethiopia is the center of diversity for durum wheat. It is one of the major cereal crops grown at altitude ranging from 1500 to 3200 m.a.s.l.

However, the most suitable areas fall within 1900 to 2700 m.a.s.l. where the annual rainfall range is between 600 and 2000 mm. It is grown over a wide range of environments different in soil fertility, incidence of weeds, disease, pests and waterlogged conditions (Yifru and Karl, 2008). The total area under cultivation for wheat in the country is estimated to be 1.61 million hectares in which durum wheat and bread wheat species are reported together as a lamp sum (CSA, 2014). Ethiopian farmers usually grow tetraploid wheat as a mixture of different morphotypes (Workineh *et al*., 2008). In Ethiopia, research on durum wheat improvement since its beginning until recently has focused mainly on improving grain yield and disease resistance (Workineh *et al*., 2008 and Tesfaye *et al*., 2008).With the expansion of agro-industries, a good processing quality durum wheat grain has become increasingly important for variety release (MoARD, 2004). Currently, there is a large market for durum wheat for domestic consumption and for export to other countries where there is a greater demand for food due to increasing populations and improving standard of living. On the other hand, limited work has been done on determining quality of Ethiopian durum wheat genotypes for pasta and other products. Keeping in view of this, the present research was initiated to estimate genetic variability and heritability in Ethiopian durum wheat genotypes for quality traits.

MATERIALS AND METHODS

Description of the Study Site

The experiment was conducted during the cropping season of 2014 at Hera Liphitu on farm research site of Yabello Pastoral and Dryland Agriculture Research Center (YPDARC). Hera Liphitu research site is located at 05°84'281"N latitude and 038°25'990" E longitude and at an altitude of 2310 m.a.s.l. The annual rainfall is 750 mm and average annual minimum temperature is 8°C and the annual maximum temperature is 25°C (National Meteorology Agency, 2014).

Experimental Materials and Design

Three durum wheat varieties released from Debre Zeit Agricultural Research Center, 13 advanced breeding lines from CIMMYT/Ethiopia and 4 released varieties from Sinana Agricultural Research Center and one farmer's cultivar as local check, a total of 21 genotypes were used for the experiment. The experiment was arranged in Randomized Complete Block Design (RCBD) with three replications.

Quality traits analysis

Random homogeneous sample of each harvested genotypes were used for laboratory analysis. Seeds samples from each genotype was harvested and analyzed separately. The samples were cleaned manually in order to remove soil particles, broken and foreign seeds. The following quality determining traits were determined.

Ash content: To determine wheat flour ash content, the procedure indicated in AACC Method 08-01.01 was used (AACC, 2000).

Vitreoussneous: Kernel vitreousity was estimated by using transmitted light according to ICC standard number 129 (ICC, 2000).

Sodium Dodecyl Sulfate (SDS) sedimentation test: The SDS sedimentation volume was measured according to AACC Method No.56-70 (AACC, 2000).

Protein content (%), Gluten content (%) and Zeleny Index (ml): were determined using Mininfra SmarT Grain Analyzer (Mininfra SmarT Grain Analyzer Operating Manual, 2013).

Wet and dry gluten content: Wet Gluten was prepared from whole meal by the Glutomatic 2200 gluten wash chamber. Gluten Index Centrifuge 2015 was used to force the wet gluten through a specially designed sieve cassette. The wet gluten is further dried in the Glutork 2020 for dry gluten content (ICC, 2000).

$$\text{Gluten index (GI)} = \frac{\text{Wet gluten remained on the seive (g)}}{Total\ wet\ gluten\ content\ (g)}$$

Wet Gluten content (WGC) = Total wet gluten (g) X 10
Dry Gluten content (DGC) = Dry gluten weight (g) X 10

Test weight (TW): The test weight was measured as described by AACC (2000) Method 55- 10.

Data Analysis

The SAS GLM (General Linear Model) procedure SAS Institute Inc (2002) was employed for the analysis of variance. Duncan's Multiple Range Test (DMRT) at 5% probability level was used for mean comparisons, whenever genotypes differences were significant.

Phenotypic and genotypic variability: The phenotypic and genotypic variances and coefficient of variations were estimated according to the methods suggested by Burton and Devane (1953).

Heritability (H^2) in broad sense for all traits was computed using the formula adopted from Allard (1960) and Falconer (1990).

Genetic advance (GA) and genetic advance as percent of mean (GA %): for each trait was computed using the formula adopted from Johnson *et al*. (1955) and Allard (1960).

Phenotypic and genotypic correlations: Phenotypic and genotypic correlations between quality traits were estimated using the method described by Miller *et al*. (1958).

RESULTS AND DISCUSSION

Analysis of Variance

Analysis of variance revealed the presence of highly significant differences among genotypes for vitresneous, gluten content, zeleny index, wet gluten content, dry gluten content and test weight. The observed significance differences among genotypes for the quality traits under study indicated the presence of genetic variations among the genotypes which in turn suggested that selection of lines can be possible in improving quality traits.

Kumar *et al*. (2009) and Asif *et al*. (2004) also reported that there is a large enough amount of genetic variability existing in wheat.

Performance of genotypes for quality traits

Vitreousity of the tested genotypes showed a wider range (52.5 - 97.9%) where the maximum value was scored for genotype Toltu and minimum value by the local cultivar. The maximum zeleny index was obtained from the genotype G2 (66.7 ml) and the minimum zeleny index was scored from the local cultivar (37.6 ml). Vitreousity and zeleny index value which are a measure of the baking quality and usually related to both higher gluten content and a better gluten quality are the two major quality parameters determining baking quality in wheat. A stronger correlation between loaf volume and zeleny sedimentation volume could be due to the protein quality influencing zeleny value.

The highest gluten content was obtained from genotype Toltu (29.8%) while the lowest gluten content was from local cultivar (16.8%) (Table 2). Wet gluten content of the studied genotypes ranged between 4.7 and 18.33%. The highest and lowest wet gluten content was obtained from genotype G2 and Hitosa, respectively. Dry gluten content of the genotypes ranges between 2.52 and 4.34%. Genotype G2 gave the maximum dry gluten content while genotype Hitosa gave the minimum dry gluten content. Genotypes with higher wet gluten content showed higher dry gluten content. However, non-significant differences were observed among genotypes for ash content, sodium dodecyl sulfate sedimentation test, protein content and gluten index. The highest and lowest test weight was obtained from genotype G12 (83.1 Kg/hl) and Toltu (76.1 Kg/hl), respectively. Test weight is a primary factor in commercial grading of durum wheat because it is easy to measure and tends to be positively associated with grain yield and processing attributes such as semolina yield.

Table 1. Description of durum wheat genotypes included in the study

S.No.	Genotypes	Year of release	Pedigree/Origin
1	Hitosa	2009	CHEN/ALTAR-84
2	Denbi	2009	AJAIA/ BUASHEN
3	Mukiye	2012	STJ3 //BCR /LKS4/3/TER-3
4	Obsa	2006	ALTAR 84 ALTO-1/AJAYA
5	Tate	2009	CD94523
6	Dirre	2012	CHEN/TE3/BUSHEN4/3/AC089CDSS92B1ZOZ
7	Toltu	2010	4/B/R9096#21001(980SN Patho)
8	G1	Elite line	CD10MS74 ELT-DZ/ HEN/2
9	G2	Elite line	CD10MS ELT-DZ (693)/ REH/HARE
10	G3	Elite line	CD10MS ELT-DZ//57*AES
11	G4	Elite line	42 IDSN// CRA/177*/4/AJA
12	G5	Elite line	CD10MS ELT-DZ//73*BUSH
13	G6	Elite line	CD10MS ELT-DZ/730ME
14	G7	Elite line	CD10MS ELT-DZ150/ AC1147//B1Z1236
15	G8	Elite line	42IDSN170
16	G9	Elite line	CD10-MCDZ-off/168#TE123547
17	G10	Elite line	CD10MS ELT-DZ273//ATR4899
18	G11	Elite line	42IDYN82
19	G12	Elite line	CD10MS ELT-DZ496/TAR4566
20	G13	Elite line	CD10MS-DDP-DZ//ATO115/ AJAYA1456
21	Local	NA	NA

G1-G13 = genotypes of durum wheat used for the study and NA= not applicable

Table 2. Mean values for quality traits of 21 durum wheat genotypes

No.	Genotypes	AC	VI	SDS	PC	GC	ZI	GI	WGC	DGC	TW
1	Hitosa	0.973^{a}	97.8^{a}	31.7 $^{a-c}$	11.7 $^{a-d}$	24^{c-g}	52.4^{e-g}	1^{a}	4.7 (2.28) ^{e}	2.28 (1.97) ^{e}	78^{b-e}
2	Denbi	0.97^{a}	96.9^{a}	34.7 ^{a}	11.4 $^{a-d}$	22.7^{c-h}	53.2^{d-g}	0.99^{a}	10.53 (3.31) $^{a-e}$	3.31 (1.95) $^{a-d}$	79^{a-e}
3	Mukiye	0.98^{a}	87.7^{a-c}	23.7 $^{a-c}$	10.9 $^{a-d}$	22.7^{c-h}	54.0^{d-f}	0.95^{a}	12.2 (3.55) $^{a-d}$	3.53 (2.00) $^{a-d}$	80.1^{a-e}
4	Obsa	0.963^{a}	95.4^{a-b}	32.0 $^{a-c}$	9.9 ^{d}	26.3^{a-e}	56.8^{b-e}	0.98^{a}	14.37 (3.79) $^{a-b}$	3.79 (2.06) $^{a-d}$	76.5^{d-e}
5	Tate	0.977^{a}	96.2^{a-b}	30.0 $^{a-c}$	12.7 $^{a-b}$	26.4^{a-d}	58.1^{b-e}	0.96^{a}	11.97 (3.45) $^{a-d}$	3.45 (1.98) $^{a-d}$	77.1^{d-e}
6	Dirre	0.877^{a}	92.1^{a-c}	28 ^{c}	10.9 $^{b-d}$	22.2^{e-h}	53.4^{d-g}	0.98^{a}	14 (3.65) $^{a-c}$	3.65 (2.01) $^{a-c}$	82^{a-b}
7	Toltu	0.95^{a}	97.9^{a}	32.0 $^{a-c}$	13.4 ^{a}	29.8^{a}	62.6^{a-c}	0.98^{a}	10.83 (3.29) $^{a-e}$	3.29 (1.94) $^{a-e}$	76.1^{e}
8	G1	0.97^{a}	97.1^{a}	31.7 $^{a-c}$	11.6 $^{a-d}$	24^{b-g}	59.4^{a-e}	0.95^{a}	18.23 (4.29) ^{a}	4.29 (2.19) $^{a-b}$	78.5^{b-e}
9	G2	0.977^{a}	95.6^{a-b}	28.3 $^{b-c}$	12.2 $^{b-d}$	28.5^{a-b}	66.7^{a}	0.87^{a}	18.33 (4.34) ^{a}	4.34 (2.19) $^{a-b}$	80.1^{a-e}
10	G3	0.97^{a}	96.4^{a-b}	29.7 $^{a-c}$	11.5 $^{a-d}$	23.1^{c-g}	53.4^{d-g}	0.99^{a}	9.23 (3.08) $^{b-e}$	3.08 (1.89) $^{c-e}$	77.3^{c-e}
11	G4	0.953^{a}	72.0^{d}	29.0 $^{a-c}$	10.0 $^{a-d}$	19.1^{h-i}	46.4^{g}	0.99^{a}	6.5 (2.57) $^{c-e}$	2.57 (1.74) $^{c-e}$	79.9^{a-e}
12	G5	0.947^{a}	82.9^{c}	32.7 $^{a-c}$	10.3 $^{a-d}$	21.9^{f-h}	55.5^{c-f}	1^{a}	6.07 (2.52) $^{c-d}$	2.52 (1.73) $^{a-d}$	81.5^{a-c}
13	G6	0.96^{a}	93.9^{a-b}	31.3 $^{a-c}$	10.9 $^{a-d}$	22.7^{c-h}	59.6^{a-e}	0.96^{a}	13.3 (3.61) $^{a-d}$	3.61 (2.01) $^{a-d}$	82^{a-b}
14	G7	0.973^{a}	97.3^{a}	31.7 $^{a-c}$	12.3 $^{b-d}$	26.3^{a-d}	60.3^{a-d}	0.98a	12.93 (3.61) $^{a-d}$	3.61 (2.04) $^{a-d}$	78.8^{a-e}
15	G8	0.977^{a}	85.9^{b-c}	31.7 $^{a-c}$	11.0 $^{a-d}$	20.8^{g-h}	48.9^{f-g}	1^{a}	8.7 (3.02) $^{b-e}$	3.02 (1.87) $^{c-e}$	80.5^{a-d}
16	G9	0.963^{a}	93.1^{a-b}	34.3 $^{a-b}$	10.6 $^{b-d}$	22.3^{e-h}	54.2^{d-f}	0.98^{a}	10.6 (3.29) $^{a-d}$	3.29 (1.94) $^{a-d}$	82^{a-b}
17	G10	0.99^{a}	95.4^{a-b}	32.3 $^{a-c}$	11.9 $^{a-d}$	25.6^{c-f}	60.4^{a-d}	0.98^{a}	12.2 (3.52) $^{a-d}$	3.52 (2.00) $^{c-e}$	78.1^{b-e}
18	G11	0.967^{a}	97.7^{a}	30.3 $^{a-c}$	11.8 $^{a-d}$	25.2^{c-f}	58.4^{b-e}	0.99^{a}	10.97 (3.48) $^{a-d}$	3.38 (1.97) $^{a-d}$	83.1^{a}
19	G12	0.963^{a}	95.7^{a-b}	33.7 $^{a-c}$	12.2 $^{a-d}$	25.6^{c-f}	60.9^{a-d}	0.97^{a}	11.67 (3.48) $^{a-d}$	3.48 (1.99) $^{a-d}$	78.4^{b-e}
20	G13	0.967^{a}	96.2^{a-b}	33.3 $^{a-c}$	12.4 $^{a-c}$	26.5^{a-c}	63.4^{a-b}	0.93^{a}	13 (3.67) $^{a-b}$	3.67 (2.04) $^{a-d}$	80.9^{a-d}
21	Local	0.973^{a}	52.5^{c}	30.3 $^{a-c}$	10.2 $^{c-d}$	16.8^{i}	37.6^{h}	0.91^{a}	10.13 (3.18) $^{b-e}$	3.18 (1.91) $^{b-e}$	77.9^{b-e}
CV (%)		3.7	5.91	9.94	10.56	8.68	6.98	4.63	16.45	0.24	2.78
Level of Significant		Ns	**	Ns	Ns	**	**	**	ns	**	**

Means with the same letter within the column are not significant at prescribed level of significant.*, ** and ns, significant at 5%, 1% probability level and non-significant, respectively. CV= coefficient of variation, AC= ash content, VI= vitreoussneous, SDS= sodium dodecyl sulfate sedimentation test, PC= protein content, GC= gluten content, ZI= zeleny index, GI= gluten index WGC= wet gluten content, DGC= dry gluten content and TW= test weight. Figures in parenthesis are square root transformed.

Table 3. Estimates of variability components (genotypic and phenotypic variances and coefficient of variations, heritability and genetic advance) for quality traits in 21 durum wheat genotypes

Traits	MSg	σ^2_g	σ^2_p	σ^2_e	GCV (%)	PCV (%)	GA	GAM (5%)	H^2_B(%)
AC	0.0015^{ns}	0.00007	0.0014	0.0013	0.84	3.89	0.004	0.38	4.76
VI	356.12**	109.02	138.1	29.05	11.44	12.86	19.11	20.95	78.96
SDS	10.93^{ns}	0.417	10.10	0.002	2.06	10.15	0.27	0.86	4.13
PC	2.55^{ns}	0.37	1.8	1.45	5.3	11.8	0.56	4.91	20.19
GC	27.82**	7.83	12.2	4.33	11.68	14.55	4.63	19.31	64.39
ZI	124.96**	36.56	51.8	15.28	10.8	12.86	10.46	18.69	70.52
GI	0.003^{ns}	0.0003	0.002	0.002	1.88	4.98	0.01	1.47	14.28
WGC	0.77**	0.153	0.463	0.31	11.62	20.2	0.46	13.77	33.1
DGC	0.05**	0.01	0.03	0.02	5.10	8.79	0.117	5.98	33.33
TW	11.93**	2.35	7.2	4.88	1.93	3.39	1.80	2.27	32.5

*, ** and ^{ns} significant at 5% and 1%, and non-significant, respectively, MSg = mean square of genotypes, σ^2_g, σ^2_p and σ^2_e = genotypic, phenotypic and environmental variances, respectively. GCV (%) and PCV (%) = genotypic and phenotypic coefficient of variations, respectively. GA and GAM (5%) = genetic advance as ratio and percent mean at 5% selection intensity, respectively, and H^2_B = heritability in broad sense in percent. AC= ash content, VI= vitreoussneous, SDS= sodium dodecyl sulfate sedimentation test, PC= protein content, GC= gluten content, ZI= zeleny index, GI= gluten index WGC= wet gluten content, DGC= dry gluten content and TW= test weight.

Table 4. Phenotypic above diagonal and genotypic below diagonal correlation coefficients of quality traits in durum wheat genotypes

Traits	AC	VI	SDS	PC	GC	ZI	GI	WGC	DGC	TW
AC		0.00ns	0.14ns	0.02ns	0.07ns	0.04ns	-0.05ns	-0.17ns	-0.16ns	-0.21ns
VI	0.03ns		0.19ns	0.41**	0.69**	0.74**	0.07ns	0.25*	0.25*	-0.04ns
SDS	0.26ns	0.25ns		0.12ns	0.25*	0.24ns	0.08ns	-0.23ns	-0.22ns	-0.14ns
PC	0.20ns	0.60**	0.12ns		0.66**	0.58**	-0.23ns	0.22ns	0.23ns	-0.46**
GC	0.14ns	0.79**	0.13ns	0.78**		0.91**	-0.27*	0.25*	0.25*	-0.38**
ZI	0.08ns	0.81**	0.17ns	0.68**	0.91**		-0.28*	0.33*	0.33*	-0.14ns
GI	-0.20ns	0.19ns	0.33ns	-0.18ns	-0.18ns	-0.23ns		-0.34*	-0.33*	0.10ns
WGC	0.04ns	0.35ns	-0.12ns	0.29ns	0.49*	0.56**	-0.64**		0.99**	0.05ns
DGC	0.07ns	0.35ns	-0.09ns	0.30ns	0.49*	0.57**	-0.62**	0.99**		0.05ns
TW	-0.33ns	-0.03ns	-0.07ns	-0.31ns	-0.29ns	0.02ns	0.00ns	0.00ns	-0.01ns	

*, ** and ns = significant at 5% and 1% probability level and non-significant, respectively. AC= ash content, VI= vitreoussneous, SDS= sodium dodecyl sulfate sedimentation test, PC= protein content, GC= gluten content, ZI= zeleny index, GI= gluten index WGC= wet gluten content, DGC= dry gluten content and TW= test weight.

It is influenced directly by thousand kernel weight, and indirectly by environmental factors such as resistance to diseases, weathering/sprouting and water or heat stress. Test weight is thus an important selection criterion in durum breeding programs.

Phenotypic and genotypic variances

Higher magnitude of differences of phenotypic and genotypic variances was observed among quality traits. The highest value of genotypic variance was computed for vitresneous (109.02) while the lowest was for gluten index (0.0003). Phenotypic variances were in the range between 138.1 for vitresneous and 0.0014 for ash content. Generally, the values calculated for phenotypic variances were higher than the corresponding genotypic variances for all quality traits. The environmental variance was also higher for traits such as vitresneous and zeleny index value. This indicated that greater influence of environmental factors for the phenotypic expression of these traits. This result was in close agreement with the findings of Mohammed *et al*. (2012) also reported higher phenotypic variances than genotypic variances for vitresneous in durum wheat. According to Sivasubramanian and Madhavamenon (1973), Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV) can be categorized as high (>20%), moderate (10-20%) and low (<10%). As per this category, moderate values of Genotypic Coefficient of Variation (GCV) from 10.8 to 11.68% was obtained for vitresneous, gluten content, zeleny index and wet gluten content. This suggested that the marked influence of environmental factors for the expression of these traits was moderate and traits are amenable to selection in the late generation. Because estimation of Genotypic Coefficient of Variation provides measure for comparing variability in the various metrical traits and better improvement through selection (Guendouz *et al*., 2014 and Kumar *et al*., 2013). The calculated values for Phenotypic Coefficient of Variation was high for wet gluten content (20.2) and moderate in the range between 10.15 and 14.55% for traits such as vitresneous, sodium dodecyl sulfate sedimentation test, protein content, gluten content and zeleny index with low in magnitude of differences of the two. This denotes that environmental factors have intermediate influence on their expression. The low values for Genotypic Coefficient of Variation (GCV) and higher difference in magnitude with the corresponding Phenotypic Coefficient of Variation (PCV) was observed for sodium dodecyl sulfate sedimentation test and protein content. This indicated that the higher influence of environmental factors in masking the expression of these traits in durum wheat genotypes and suggested the difficult to improve. Low values for both Genotypic Coefficient of Variations (GCV) and Phenotypic Coefficient of Variation (PCV) were computed for traits such as ash content, gluten index, dry gluten content and test weight this indicates the large influence of environment on the expression of these traits and the practically difficult for their improvement. Early generation selection for such traits based on phenotypic evaluation of single plants and/or in single environments might rarely been effective.

Similar findings were reported by Bushan *et al*. (2013); Bilgin *et al*. (2011, 2010); Mohammed *et al*. (2011); Ashfaq *et al*. (2014) for test weight.

Heritability and genetic advance

Low to high magnitudes of heritability and genetic advance as percent of mean was observed for different traits (Table 3). The computed values for heritability in broad sense ranged from 4.13 to 78.96% while it was ranged from 0.38 to 20.95% for genetic advance as percent of mean. As suggested by Robinson *et al*. (1955), heritability in broad sense can be categorized as high (> 60), moderate (30 – 60%) and low (< 30%). Similarly, genetic advance as percent mean can be categorized as high (> 20), moderate (10 – 20 %) and low (< 10%) (Johnson *et al*., 1955). In this study, both heritability and genetic advance as percent of mean values were high for vitreoussneous. This suggested that this trait is responsive for selection and single plant selection is much effective for its improvement. Heritability estimates would be reliable if accompanied by a high estimate of genetic advance as percent of mean (Singh and Choudhry, 1985). In the present study, heritability values were high to moderate while the values for genetic advance as percent of mean were moderate for gluten content, zeleny index and wet gluten content. High to moderate heritability values but low genetic advance as percent of mean values were recorded for dry gluten content and test weight. On the other hand, low values were computed for both heritability and genetic advance as percent of mean for ash content, sodium dodecyl sulfate sedimentation test, protein content and gluten index. This suggested that the improvement of these traits in durum wheat is difficult through selection breeding. This may be due to the higher influence of environment on these traits and the presence of non-additive type of gene action that limit the scope of improvement through selection of high performing genotypes (Ali *et al.,* 2008). Different studies suggested that, it is important to consider both genetic parameters (heritability and genetic advance) to suggest that whether the trait is amenable for selection or not for its improvement than depending on heritability of the trait alone.

Association of Characters

The association of vitresneous with protein content, gluten content and zeleny index was positive and highly significant both at genotypic and phenotypic levels. Wet gluten content and dry gluten content were significantly and positively associated with vitresneous at phenotypic level and non–significant at genotypic level in line to the result reported by Bilgin *et al*. (2010). The degree of vitresneous of durum wheat is related to protein and its composition in the grain signifies the positive correlation. Protein content was significantly and positively correlated with gluten content and zeleny index both at phenotypic and genotypic levels. Gluten content was strongly and significantly correlated with protein content, zeleny index, wet gluten content and dry gluten content at phenotypic and genotypic levels. The gluten proteins, the gliadins and glutenins, constitute up to 80-85% Faris (2011) of total flour protein in wheat properties are mainly due to variations in structure, amount and proportion of the different proteins that determine the viscoelastic properties are responsible for the correlation of gluten content to zeleny index and protein content.

The phenotypic and genotypic correlation between zeleny index and wet gluten content and dry gluten content showed highly significant and positive. The phenotypic and genotypic correlations among wet gluten content and dry gluten content were highly significant and positive in compliance with Mohammed *et al*. (2012) reports. Quality traits significantly and positively correlated among themselves and provide information for durum wheat breeders to able to express high and good technological quality. Protein content has negatively associated with test weight at phenotypic level in contrast to Mohammed *et al*. (2012) that reported positive association. Significant and negative association was exhibited between gluten content and gluten index and gluten content and test weight at phenotypic level. The correlation between zeleny index and gluten index was negative at phenotypic level. The negative and strong relationship of traits indicated that they had certain inherent relationship among themselves and these characters should be considered as selection criteria for improvement of grain yield and quality in durum wheat.

Summary and Conclusion

Information on the nature and magnitude of genetic variability present in a crop species is important for developing effective crop improvement program. In addition, estimation of the magnitude of variation within germplasm collections for important plant attributes will enable breeders to exploit genetic diversity more efficiently. Heritability of any trait is a significant genetic parameter for the selection of efficient improvement methods in durum wheat breeding. Single plant selection in the earlier generation may be effective for traits that have high heritability as compared to traits with low heritability and environment is another factor that interacts to genetic constitution and influence heritability.

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