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GENETIC VARIABILITY IN SUNFLOWER (*HELIANTHUS ANNUUS* L.) FOR ACHENE YIELD AND MORPHOLOGICAL CHARACTERS

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ABSTRACT
The research was conducted in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during year 2011. Ten accessions of sunflower were evaluated for genetic variability and association of morphological traits among themselves and with achene yield. The data were recorded on quantitative *i.e*. days to 50% flowering, days to 50% maturity, plant height, number of leaves per plant, leaf area, head diameter, % filled achene, achene weight per head and 100 achene weight and qualitative traits *i.e*. lead habit, leaf shape, head shape, head angle at maturity, achene size, achene stripes and achene colour and subjected to analysis of variance, correlation and path coefficient analysis. Differences among the accessions were significant for all the traits under study except % filled achenes. The accession A-79 showed better performance for number of leaves per plant, leaf area, head diameter, % filled achenes, 100 achene weight and achene weight per head.HBRS-1, G-33 and G-8 also had appreciable performance for many traits. Genotypic correlations of achene weight were positive and significant with leaf area, number of leaves per plant, head diameter and 100 achene weights. Phenotypic correlations of all the traits were non-significant with achene weight per head. The trait 100 achene weight had the highest direct effect on achene weight per head followed by leaf area and days to 50%maturity. Days to 50% maturity had the highest positive indirect effect on achene weight per head via head diameter followed by head diameter and leaf area through 100 achene weight. It is suggested that 100 achene weight, leaf area and head diameter may be used in breeding program for selection of high yielding sunflower types.

KEYWORDS: Sunflower, genetic variability, genotypic correlation, phenotypic correlation and path coefficient analysis

INTRODUCTION

Edible oil is the basic requirement of the human body because it is very important for the escalation and improvement of body. But there is a gap between the consumption and production of edible oil in Pakistan. Pakistan is importing 2.148 million tons edible oil of worth Rs. 216.4 billion (Economic Survey of Pakistan, 2012-2013). There is need to focus on conventional as well as non-conventional oilseed crops to fill the gap between consumption and production. Sunflower *(Helianthus annuus* L.) is non-conventional crop introduced in Pakistan during 1960's and has great potential to produce the highest oil yield per hectare. Its seed, called as achene, is very crucial source of edible oil for cooking purposes (Wahid *et al.,* 2008). In Pakistan sunflower is grown on 0.70 million acres, its seed and oil production is 0.144 and 0.378 million tons respectively (Economic Survey of Pakistan, 2012-2013). Most of the sunflower seed is imported in the country that is actually not bred for our environment. That's why; it gives low yield due to the adaptation problem (Kokhar *et al.,* 2006).

Oil content of sunflower kernel ranges from 48-53% whilst in seed from 28-35% (Reddy, 2006). Sunflower oil is premium oil due to its beam colour, taste, high smoke point, good nutritional quality, towering level of unsaturated fatty acids and lack of linolenic acid. It has the sturdy oxidative stability so it can be used as cooking oil. Sunflower is short duration crop (95-120 days) so; it fits in any cropping pattern of Pakistan. It also requires less agronomic practices for the better yield. But farmers are focusing on major crops instead of sunflower as an oilseed crop. Regrettably its production in Pakistan is very stumpy compared to its requirement. For the enhancement of oil production we need to increase achene yield of sunflower. Genetic variability is very crucial item in the breeding programs (Sujatha *et al*., 2002). Genetic similarities and differences existing in the genotypes are utilized efficiently as genetic resource in the breeding programs (Safavi *et al.,* 2010). Magnitude and the nature of the genotypic variation and the non genotypic variation in the morphological characters is the stipulation for the progress of the breeding process (Safavi *et al*., 2011). Achene yield is a quantitative character which is influenced by different traits. Association is determined between the achene yield and its related traits for the improvement of yield in sunflower. This may also be helpful in the identification of such traits which have direct or indirect effects on achene yield (Hladni *et al*., 2011).Correlation analysis measures all positive and negative effects of traits on achene yield. Simple correlations are partitioned into genotypic and phenotypic correlations. Higher magnitude of genotypic correlation coefficient than phenotypic indicates the absence of environmental effects (Ashok *et al.,* 2000). But the limitation is that it only measures the relationship among the characters. Path coefficient analysis quantifies the interrelationship of different yield components and their direct or indirect effects on seed yield (Markinkovic, 1992). Correlation and path analyses can be very helpful

to develop the selection criteria for breeding program. Present study was conducted to estimate genetic variability among sunflower accessions for achene yield and its related traits. Another objective of this study was determination of the relationship among various traits, and direct and indirect effects of these traits on achene yield. This will help in the development of criteria for the selection of high yielding sunflower types in future breeding programmes.

MATERIALS & METHODS

Experimental Condition

The research work was conducted in the research fields of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Faisalabad is situated in the rolling flat plains of North East Punjab. It is between longitudes 73˚-06́ east, latitude 30˚-26́ north and altitude is 184.4 m. It possesses arid climate and loamy soil in field with the 0.53% organic content. Monthly average maximum and minimum temperatures and total rainfall during the research period is presented in Figure I (a) and Figure I (b) respectively.

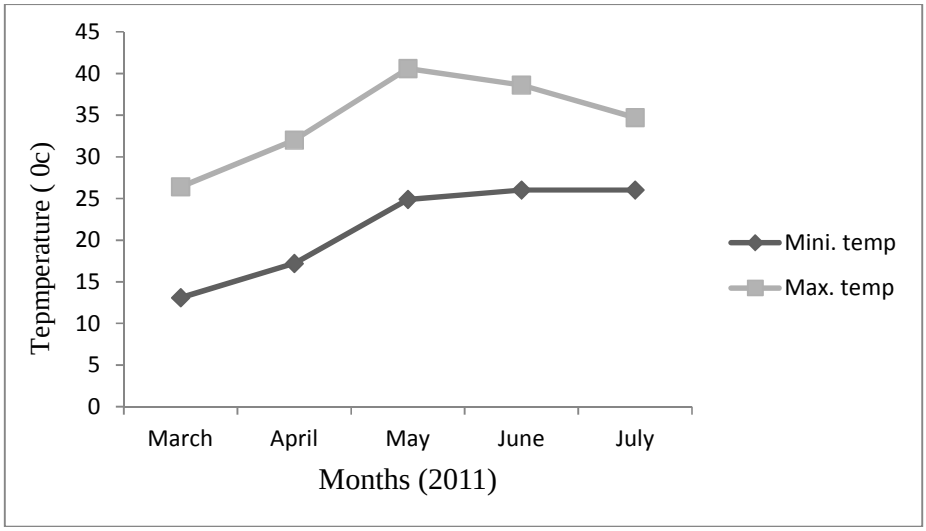

FIGURE I (a) Monthly average max. and mini. temperature (ºC) during crop season 2011

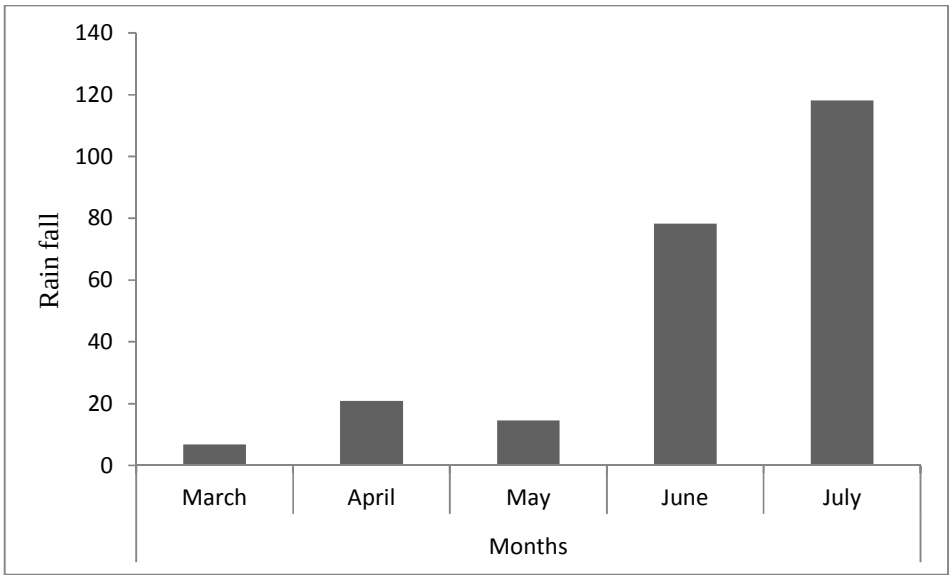

FIGURE I (b) Monthly total rainfall (mm) during crop season 2011

Experimental Material

Ten accessions of sunflower (Table I) developed and maintained by the Oilseed Research Group, Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad were used in this experiment.

TABLE I: Sunflower accessions used in the present study

Sr. No.	Name of accession	Sr. No.	Name of accession
1	HBRS-1	6	G-33
2	A-79	7	G-56
3	A-48	8	G-8
4	A-75	9	G-64
5	G-61	10	A-23

Experimental Layout

The experiment was laid out in a randomized complete block design with three replications in spring season 2011. One row of 3.6 m of each accession per replication was grown. Dibbler method was used for sowing maintaining row to row and plant to plant distance of 0.75 m and 0.25 m, respectively. Before sowing DAP and urea was applied at the rate of 40 kg ha^{-1}. At the time of flowering urea was again applied at the rate of 40 kg ha^{-1}. All other cultural and agronomic practices were performed uniformly for all the experimental units.

Data Recording

Ten representative plants of each accession were taken randomly from each replication and data were recorded on quantitative characters *i.e.* days to 50% flowering, days to 50% maturity, plant height (cm), number of leaves per plant, leaf area (cm^2), head diameter (cm), % filled achene, achene weight per head (g) and 100 achene weight (g). Qualitative characters were also observed i.e. lead habit, leaf shape, head shape, head angle at maturity, achene size, achene stripes and achene colour.

Statistical analysis

The data were analyzed statistically to determine the genetic variability following Steel *et al*. (1997). To find the strength of relationship among yield and its related traits correlation analysis was used as proposed by Kwon and Torrie (1964). Path coefficient analysis was performed to examine the direct and indirect effects of morphological traits on achene yield as proposed by Dewey and Lu (1957).

RESULTS &DISCUSSION

Quantitative characters

Genetic variability

Genetic variability is very crucial tool for the improvement of achene yield in sunflower. The mean squares from analysis of variance of different characters are presented in Table II. Accessions had highly significant differences for all the characters except % filled achene. This suggests the presence of genetic variability which can be exploited in next breeding program. The mean comparisons of accessions for different characters are presented in Table III. Days to 50% flowering ranged from 69.7 to 76, days to 50% maturity from 98 to 110, plant height from 153.4 to 202.2 cm, number of leaves per plant from 22 to 31, leaf area from 24.5 to 33.6 cm^2, head diameter from 21.4 to 27.2 cm, % filled achene from 174 to 180%, achene weight per head from 31.1 to 37.8 g, 100 achene weight from 5.5 to7.12 g.

TABLE II: Mean squares of sunflower accessions for various plant characters

SOV	DF	DTF	DTM	PH	NOL	LA	HD	%FA	AW/H	100AW
Accessions	9	112.4**	403.3**	7891**	208**	269**	93.9**	111	148**	8.14**
Replications	2	6619	23446.3	5600	2524.3	2513.6	106.7	87.8	5123	230.6
Error	288	7.7153	19.79	1302.3	47.23	42.55	25.03	121.03	53.82	0.44

**= significant at 0.01 probability level

SOV= Source of variations, **DF**= degrees of freedom

DTF= Days to 50% flowering, **DTM**= Days to 50% maturity, **PH**= Plant height, **LA**= Leaf area, **NOL**= Number of leaves per plant, **HD**= Head diameter, **FA**= % Filled achene, **100AW**= 100 achene weight, **AW/H**= Achene weight per head

Table III: Mean comparisons of sunflower accessions for various plant characters

Accessions	DTF	DTM	PH	NOL	LA	HD	%FA	AW/H	100AW
HBRS-1	71.7	100.7	153.4	29	33.2	23.6	177	33.7	6.1
A-79	73.3	102.3	172.7	31	33.6	26.4	177	37.8	7.12
A-48	73.3	104.3	162.6	24	26.3	22.9	177	35.9	6.83
A-75	73.3	110	158.6	24	26.5	24.9	180	31.6	6.2
G-61	75.3	104.3	173.6	24	25.9	21.4	178.5	34.5	5.5
G-33	72.3	105.3	200.5	27	28.8	23.9	180	31.1	6.3
G-56	73.3	106.3	169.2	22	24.5	26.2	175.5	31.5	5.6
G-8	75.7	98.3	178.5	27	29.5	27.2	177	36.1	5.9
G-64	76	103.2	181.4	27	29.4	23.9	175.5	34.1	5.7
A-23	69.7	98	202.2	26	28.6	24	174	35.1	6.03

DTF= Days to 50% flowering, **DTM**= Days to 50% maturity, **PH**= Plant height, **LA**= Leaf area, **NOL**= Number of leaves per plant, **HD**= Head diameter, **FA**= % Filled achene, **100AW**= 100 achene weight, **AW/H**= Achene weight per head

Qualitative characters

Performance of the sunflower accessions for qualitative traits is presented in Fig. II, III, and IV. It was observed that 97% plants of HBRS-1, A-75, G-66 and G-33 had head angle 180˚. More than 90% plants of all accessions had 180˚ head angle except G-8, G-64 and A-23 (Fig. II). A small percentage of plants of these accessions had head angle 135˚. Heads of 97% plants of A-48, G-56 and G-8

accessions were concave type. More than 90% plants of all accessions had concave shaped head except A-79 and A-23 (Fig. II). A very few plants had convex, flat and misshapen type of head shapes. All accessions had 100% plants with cordate leaf shape except A-79, A-48, G-64 and A-23 (Fig.III). Triangular type of leaf shape was also observed in some of the plants of these accessions. The 100% Plants of all accessions had semi erect leaf habit except G-61 and G-56. (Fig.III). Semi erect to horizontal leaf habit was also observed in few plants. The accession G-33 had 97% plants with lateral type of achene stripes. More than 80% plants of all accessions had lateral achene stripes except HBRS-1, A-79, G-56 and G-64 (Fig. IV). A very few percentage of plants with marginal, both type lateral and marginal was also found. It was noticed that 97% plants of A-48 had medium type of achene size. Achenes of more than 70% plants of all accessions except HBRS-1 and A-79 were of medium size (Fig. IV). Small and large achene size was also observed in few plants. Black achene colour was observed in 100% plants of A-75 and A-48 (Fig. IV). More than 90% plants of all accessions had black colour except A-23. A very little percentage of plants had grey, white medium and dark brown achenes.

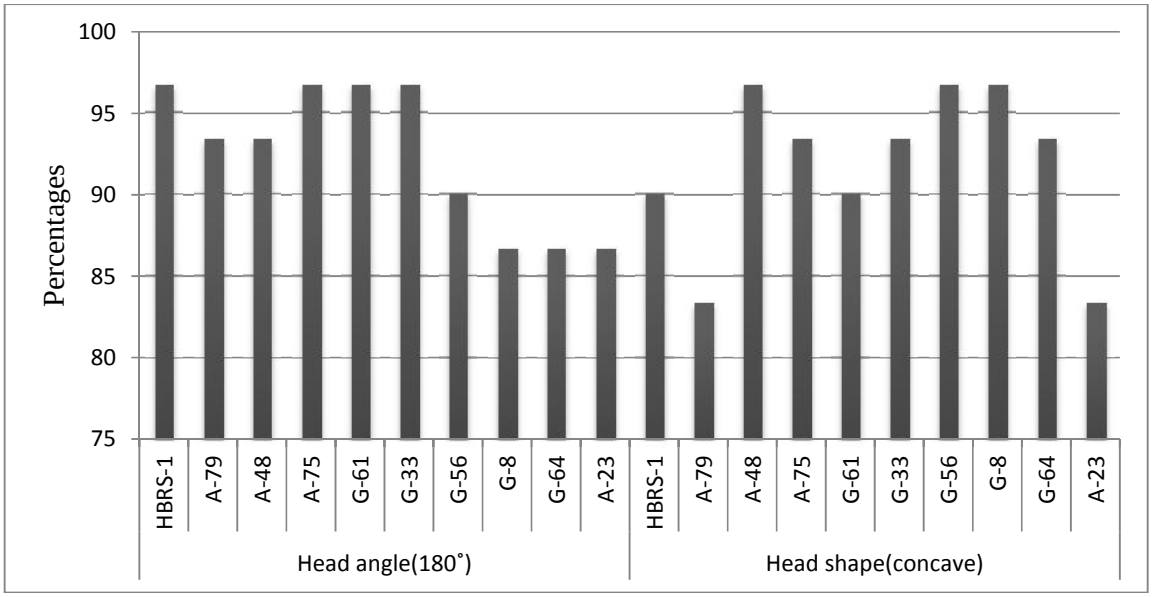

FIGURE II: Performance of sunflower accessions for head angle and head shape

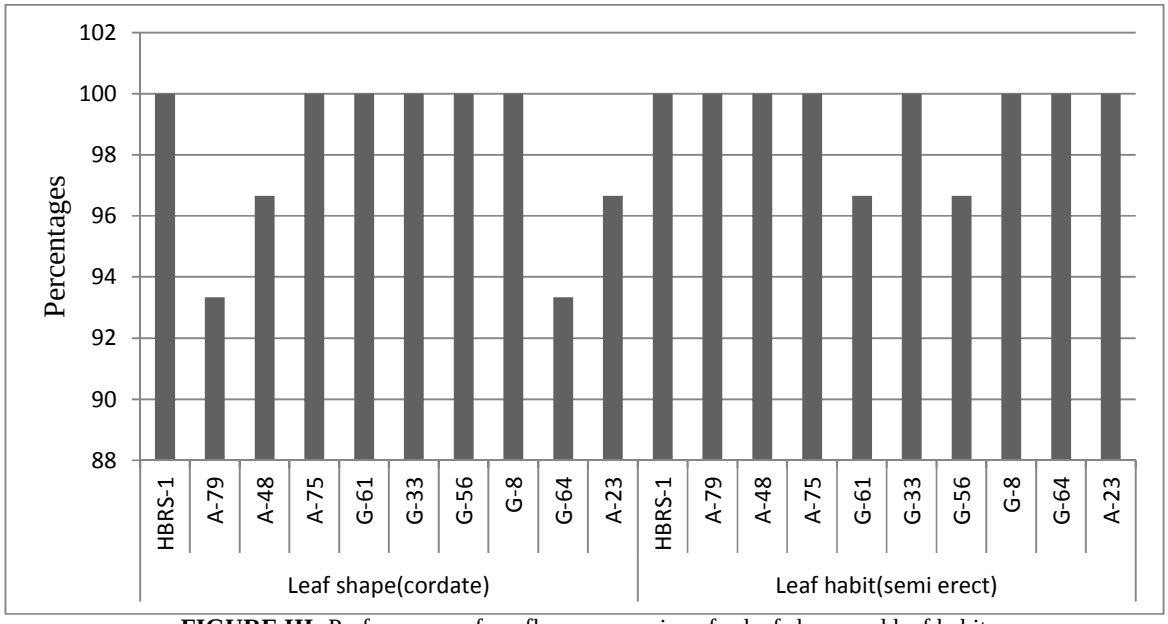

FIGURE III: Performance of sunflower accessions for leaf shape and leaf habit

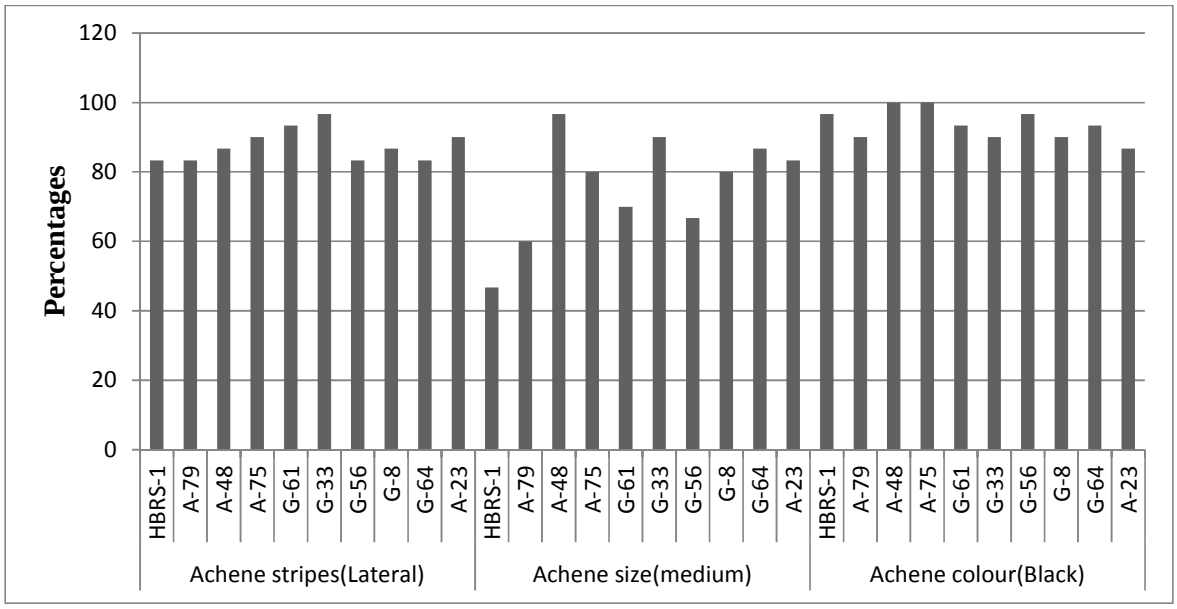

FIGURE IV: Performance of sunflower accessions for achene stripes, size and colour

Correlation and Path coefficient analysis

Genotypic and phenotypic correlation coefficients among various traits are presented in Table IV. Most of the genotypic correlation coefficients were higher than phenotypic correlation coefficients, it was indicating that environmental effects were very low. Number of leaves per plant, leaf area, head diameter and 100 achene weights had positive and significant genotypic correlations with achene weight per head. Phenotypic correlation coefficients of all the traits were non-significant with achene weight per head. Genotypic correlations of days to 50% flowering, days to 50% maturity, plant height, leaf area, number of leaves per plant, head diameter, filled achene percentage and 100 achene weight were significant with achene weight per head.

Path analysis presented direct and indirect effects of different traits on achene weight per head (Table V). The trait 100 achene weights followed by leaf area, days to maturity and number of leaves per plant had positive direct effects on achene weight per head. While other traits had negative direct effects on achene weight per head. Days to 50% maturity had the highest positive indirect effect through head diameter followed by head diameter and leaf area via 100 achene weight on achene weight per head.

TABLE IV: Genotypic (upper value) and phenotypic (lower value) correlation coefficients among various characters of sunflower accessions

Characters	DTF	DTM	PH	LA	NOL	HD	FA	100AW
DTM	0.342							
	0.151							
PH	-0.342	-0.472						
	-0.173	-0.234						
LA	-0.178	-0.594	-0.237					
	-0.183	-0.460	-0.005					
NOL	0.014	-0.179	0.132	0.318				
	0.029	-0.110	-0.145	0.132				
HD	0.311	-0.510	-0.333	0.467	0.313			
	0.001	-0.226	-0.101	0.292	0.042			
FA	0.226	-0.117	0.948*	-0.640*	0.164*	-0.530*		
	0.112	-0.232	0.469	-0.286	0.085	-0.215		
100AW	-0.390	0.960	-0.150	0.670*	0.135*	0.690*	0.850*	
	-0.238	0.100	-0.130	0.180	-0.060	-0.218	-0.484	
AW/H	-0.830*	-0.075*	-0.011*	0.580*	0.137*	0.056*	-0.740*	0.870*
	-0.454	-0.053	-0.053	0.215	-0.147	0.111	-0.372	0.471

* = significant at 0.05 probability level

DTF= Days to 50% flowering, **DTM**= Days to 50% maturity, **PH**= Plant height, **LA**= Leaf area, **NOL**= Number of leaves per plant, **HD**= Head diameter, **FA**= % Filled achene, **100AW**= 100 achene weight, **AW/H**= Achene weight per head

TABLE V: Direct (bold diagonal) and indirect effects of various characters on achene weight per head of sunflower accessions

Variables	DTF	DTM	PH	LA	NOL	HD	FA	100AW	r_g
DTF	-0.65	0.07	0.01	-0.05	-0.01	-0.04	-0.02	-0.15	-0.84
DTM	-0.22	0.21	0.02	-0.18	-0.01	0.67	0.011	0.04	-0.08
PH	0.22	-0.10	-0.04	-0.01	0.01	0.04	-0.09	-0.06	-0.01
LA	0.12	-0.12	0.001	0.30	0.03	-0.07	0.06	0.26	0.58
NOL	-0.01	-0.04	-0.01	0.12	0.08	-0.05	-0.02	0.05	0.14
HD	-0.20	-.11	0.012	0.14	0.03	-0.13	0.05	0.27	0.06
FA	-0.15	-0.02	-0.035	-0.19	0.01	0.07	-0.08	-0.34	-0.74
100AW	-0.15	0.02	0.006	0.20	0.01	-0.09	-0.08	0.39	0.87

DTF= Days to 50% flowering, **DTM**= Days to 50% maturity, **PH**= Plant height, **LA**= Leaf area, **NOL**= Number of leaves per plant, **HD**= Head diameter, **FA**= % Filled achene, **100AW**= 100 achene weight, **AW/H**= Achene weight per head

DISCUSSION

Genetic variability in sunflower accessions for morphological traits had also been reported by many researchers (Sujatha *et al.*, 2002; Nehru and Manjunath 2003; Ozer *et al.*, 2003; Rao *et al.*, 2003). In literature Ahmad *et al*. (2001); Marinkovic (1992); Sasikala *et al.* (2000); Mehmood and Mehdi (2003); Moorthy (2004); Vidhyavathi *et al.* (2005); Goksoy (2009); Kaya *et al.* (2008); Tabrizi *et al.* (2009), Anandhan *et al.* (2010); Sowmya *et al.* (2010) and Kalukhi *et al.* (2010) reported mean ranges for days to 50% flowering from 47.50 to 85.5, days to 50% maturity from 89 to 114, plant height from 65.40 to 266.7 cm, number of leaves per plant from 11 to 53, leaf area from 21.43 to 51.51 cm², head diameter from 3.40 to 55 cm, % filled achene from 179 to 190%, achene weight per head from 24.60 to 89.48 g, 100 achene weight from 1.65 to 17.7 g. All the character ranges in our breeding material are comparable with the ranges found in literature. The comparison indicates that further improvement of these accessions for many plant traits can be made through selection of superior plants and discarding the plants with inferior performance. The accession A-79 showed better performance for number of leaves per plant, leaf area, head diameter, %filled achenes, achene weight per head and 100 achene weight. The accessions HBRS-1, G-33 and G-8 were good in performance for different characters. Accession HBRS-1 performed better for days to 50% flowering, days to 50% maturity, number of leaves per plant, leaf area and % filled achenes. Similarly accessions G-33 and G-8 showed good performance for days to 50% maturity, leaf area, head diameter, % filled achenes and achene weight per head. So, these accessions may be used in breeding program for the enhancement of achene yield and its related traits in sunflower to increase the local production of edible oil to achieve self sufficiency in this sector. Abdelgawad *et al.*, 1987 reported semi erect type of leaf habit for different sunflower accessions.

Abdelgawad *et al.* (1987); Singh and Labana (1990), Yasin and Singh (2010) had also reported positive and significant correlations of leaf area with head diameter. Ahmad *et al*. (2001); Marinkovic (1992); Sasikala *et al.* (2000); Mehmood and Mehdi (2003); Moorthy (2004); Vidhyavathi *et al.* (2005); Goksoy (2009); Kaya *et al.* (2008); Tabrizi *et al.* (2009), Anandhan *et al.* (2010); Sowmya *et al.* (2010) and Kalukhi *et al.* (2010) showed that head diameter had significant genotypic correlation for the achene weight and 100 achene weight. Mehmood and Mehdi (2003); Kaya *et al*. (2008); and Sowmya *et al.* (2010) reported that day to 50% flowering, number of leaves, 100 achene weight had significant correlations with achene yield. Plant height, filled achene percentage and head diameter had significant correlations with achene weight per head reported by Dagustu *et al.* (2002); Kaya *et al.* (2003); Kaya and Atakisi (2003); Dusanic *et al.* (2004); Anandhan *et al.* (2010) and Sowmya *et al.* (2010).

Ahmad *et al*. (2001); Marinkovic *et al*. (1992); Patil *et al*. (1996); Lal *et al*. (1997); Habib *et al.* (2006); Kolghi *et al.* (2011) also reported that 100 achene weight had positive direct effect on achene weight per head. Kalukhi *et al.* (2010) reported that head diameter had indirect positive effect on achene yield via 100 achene weight. The trait 100 achene weights had positive indirect effects through days to 50% maturity, plant height, leaf area and number of leaves per plant reported by Farratullah *et al.* (2006); Madihavilatha *et al.* (2004); Arshad (2007) and Behradfar *et al*. (2009). A selection criterion is developed on the basis of correlation and path analyses. The traits 100 achene weight, leaf area and head diameter may be used for the improvement of achene yield. As genotypic correlations of 100 achene weight and leaf area with achene weight per head were significant and positive.

CONCLUSION

Presence of genetic variability in the present breeding material may be exploited in the hybridization programmes or for the development of better yielding hybrids in sunflower. Performance of the accessions A-79, HBRS-1, G-33 and G-8 for the traits under study suggests their use in the future breeding programs for the improvement of achene yield. Interrelationship of 100 achene weight, leaf area, head diameter with achene yield and other plant traits suggests that these traits may be used as criteria for indirect selection of sunflower types with better yield potential.

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