Correlation and path coefficient analyses of yield components in S_3 progenies of *Helianthus annuus*

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Abstract: Fifteen accessions of Sunflower were evaluated for genetic variability and association of morphological traits with achene yield. The trial was laid out following Randomized Complete Block Design with three replications. The data were recorded on traits and subjected to statistical analysis. The differences among accessions were highly significant for studied traits. Genotypic correlation coefficients were higher than phenotypic correlation coefficients suggesting low environmental effects. Plant height had the highest positive significant genotypic and phenotypic correlation with achene yield. All studied traits had positive direct effects on achene yield. Head diameter followed by oil yield had the highest direct effect on achene yield. Palmitic acid had shown the highest positive indirect effect on achene yield through number of achenes. Number of achenes followed by % filled achenes had the highest broad sense heritability and genetic advance indicating higher genetic contribution than environment. On the basis of correlation and path analysis it may be suggested that plant height, days to 50% maturity, head diameter, filled achene percentage, 100 achene weight and achene yield may be used for selection to improve sunflower oil yield.

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Introduction

Sunflower (*Helianthus annuus* L.) is a very important oilseed crop and stands at fourth position in oilseed crops ranking in the world (Zia *et al.,* 2013). Sunflower (*H. annuus* L.) has become the most important oil crop as it contributes 30% in domestic edible oil crop. Sunflower achenes are very rich in protein and essential fatty acids. These nutrients are essential for good health of the nerves, brain, eyes and for the general health. The achene itself is edible and its oil is used for frying and cooking purpose. It is also used as poultry feed. The rapid expansion of domestic oilseed production has been the major concern for decision makers because of increasing import bills. Amongst oilseed crops, sunflower is one of the important oil crops, due to its higher yield potential, wider adaptability and shorter growth period. In Pakistan, sunflower was introduced in early seventies and now has become the second most important cash crop in the country (Arshad *et al*, 2010). Pakistan is 76% deficit in edible oil production and sunflower can help in reducing this gap in production and consumption (Pakistan Economic Survey, 2013-2014). Relationship of important plant traits is explained by correlation. Environmental effects have less influence as magnitude of genotypic correlation is higher than their respective phenotypic correlations (Ashoke *et al.* 2000). But the limitation is that it only measures the relationship among the characters. Path coefficient is another analysis which quantifies this relationship in the form of direct and indirect effects of causal variables on resultant variable (Marinkovic, 1992).The genetic parameters like heritability and genetic advance associated with plant traits would help in selecting the target traits and also the populations expressing these traits. These populations could then be crossed through controlled pollinations to converge these characters of genetic importance. The objective of the present scientific endeavor is thus two fold, first is to identify plant and achene characters having strong contribution and relationship with yield and then on the basis of these characters selection of lines and populations to hybridize for breeding program. This would generate selection criteria to be used for hybridization and afterward selection in segregating generations. The scientific information generated through these activities would be of great importance to the plant breeders in planning and executing their breeding programs meant for genetic improvement in achene yield.

Material and methods

The research was carried out in the experimental area of the Department of Plant Breeding and Genetics. University of Agriculture Faisalabad, Pakistan during crop growing season 2014. Experimental material was comprised of 15 sunflower populations of S_3 progenies including A.10.11,

A.11.1.3, A.10.1.3, A.4.11, A.11.1.4, A.11.1.5, A.10.1.4, A.16.1, A.12.2, B.2.1, C.2.17.2, C.3.3.2, C.2.19, C.2.10 and C.4.15. These populations were sown in triplicated Randomized Complete Block Design under normal conditions. Row to row and plant to plant distances were kept 75 and 25 cm respectively. Ten guarded plants from each entry were tagged to record data on individual plant basis. Data were recorded for these parameters: plant height (cm), days to 50% flowering, days to 50% maturity, head diameter, number of achenes per head, 100-achene weight, filled achenes per head, achene yield per plant, oil contents, protein contents, fatty acid composition (oleic acid, linoleic acid and palmitic acid).

Statistical analysis

The data are analyzed for analysis of variance given by Steel *et al*. (1997). The means of various progenies for each character is calculated and compared using Duncan's New Multiple Range Test. Phenotypic and genotypic correlation coefficients are calculated according to Kwon and Torrie (1964). Procedure of path analysis is used as given by Dewey and Lu (1959). Heritability and genetic advance are computed as described by Burton and DeVane (1953).

Results and discussion

The differences among accessions were highly significant for studied traits. It is indicated that studied material values are compatible with the literature based range. The results for genotypic and phenotypic correlations and path coefficient analyses are presented in the Table 1, 2 and 3 respectively.

Achene yield vz other characters

Achene yield per plant had positive and significant correlation with plant height, days to 50% maturity, head diameter, 100 achene weight, protein yield and palmitic acid at both genotypic and phenotypic level. Several other researchers also reported a significant and positive correlation of achene yield per plant with head diameter (Sowmya *et al*., 2010 and Anandhan *et al*., 2010), 100-achene weight (Anandhan *et al*., 2010) and with plant height (Anandhan *et al*., 2010) also showed the same results.

Between other characters

Plant height had positive and significant genotypic correlation with days to 50% maturity, achene yield, 100 achene weight, palmitic acid and oil yield. Plant height had significant genotypic and phenotypic correlations with achene yield. Amorim *et al*., (2008) and Sowmya *et al*., (2010) also showed the same results. Head diameter had negative significant genotypic correlation with number of achenes, oleic acid and oil yield. Zia *et al*., (2013) and Memon *et al*. (2014) explained highly significant and positive correlation of head diameter with achene yield. Genotypic correlation of 100 achene weight was positive and significant with plant height, days to 50% maturity, head diameter, achene yield, oleic acid and palmitic acid. Phenotypic correlation of 100 achene weight was positive and significant with plant height, achene yield, oleic acid and palmitic acid. Machikow and Saetang (2008), Kholghi *et al*., (2011); Zia *et al*., (2013); Ali *et al*., (2013); Ali *et al*., (2014ab) and Memon *et al*., (2014) reported that achene weight had significant and positive correlation with seed yield. Oleic acid showed genotypic and phenotypic positive and non-significant correlation with linoleic acid in contrast to palmitic acid which was non-significant but negative. It had significant positive genotypic correlation with 100 achene weight and oil yield. Velasco *et al*., (2007) reported a positive significant correlation between oleic acid and palmitic acid at both genotypic and phenotypic levels. Linoleic acid showed negative and non-significant genotypic and phenotypic correlations with plant height and days to 50% flowering. Tahmasebi-Enferadi *et al*., (2004) reported negative and significant correlation between linoleic acid and oleic acid. Palmitic acid showed positive and significant genotypic and phenotypic correlations with plant height, head diameter, achene yield, 100 achene weight and protein yield. Velasco *et al*., (2007) reported positive significant correlation between palmitic acid and oleic acid at both genotypic and phenotypic levels.

Path coefficient analysis

The coefficient is a standard regression coefficient technique which measures the effect of different components upon achene yield of plant which effects directly and indirectly, by dividing the genetic correlation coefficient. Such information may be useful in prediction of correlated responses of different traits to directional selection. Keeping sunflower achene yield per plant as a resultant variable the results attained in the path coefficient studies on plant performances traits mentioned above. Direct and indirect effects of various quantitative traits on achene yield are presented in Table 3. All studied traits showed positive direct effect on achene yield. Head diameter had the highest positive direct effect. High positive direct effect was also reported by Moorthy (2004) for head diameter and Gouri-shankar *et al*. (2006) for 100-achene weight. Oleic acid and palmitic acid had positive indirect effects for majority of the traits. Plant height, head diameter, 100 achene weight, protein yield and palmitic acid had positive significant genotypic and phenotypic correlations coupled with high direct effect on achene yield. Genetic correlation between different traits may be due to pleiotropy, linkage or developmentally induced functional relationships (Sowmya *et al*., 2010; Hassan *et al*., 2013; Imran *et al*., 2015). It is evident that the

traits which were involved in producing the high values of genotypic and phenotypic correlations also have the high values of path coefficient analysis. Selection of the traitshaving significant genotypic correlation along with the highest direct effects may be worthwhile in future breeding program for improved achene yield.

Table 1. Genotypic correlation coefficient of various characters among the Sunflower accessions

Traits	DTF	DTM	HD	NOA	AY	FA%	100 AW	PY	OA	LA	PA	OY
PH	0.081	0.321*	0.077	-0.028	0.719*	0.0827	0.478*	0.086	-0.028	-0.147	0.536*	0.533*
DTF		0.353*	-0.268*	0.558*	-0.389*	0.222*	-0.420*	0.104	-0.398*	-0.019	-0.492*	0.032
DTM			-0.216*	0.099	0.173*	-0.179	0.204*	-0.238*	-0.143	0.132	-0.187*	0.086
HD				-0.169*	0.222*	0.158	0.186*	0.126	-0.167*	0.134	0.273*	-0.526*
NOA					-0.158	-0.126	-0.197*	0.413*	-0.146	0.488*	-0.275*	0.351*
AY						-0.424*	0.609*	0.264*	-0.087	0.032	0.836*	0.077
FA%							-0.202*	-0.269*	-0.046	-0.424*	-0.194*	0.009
100 AW								-0.147	0.277*	0.001	0.513*	-0.825*
PY									-0.314*	0.153	0.252*	0.566*
OA										0.096	-0.109	0.546*
LA											-0.289*	0.339*
PA												0.344*

Plant height (PH), days to 50% flowering (DTF), days to maturity (DTM), head diameter(HD), No. of achenes (NOA), achene yield(AY), filled achene percentage (FA%), 100 achene weight (100 AW), protein yield (PY), oil yield (OY), oleic acid(OA), linoleic acid (LA), palmitic acid (PA)

Table 2. Phenotypic correlation coefficient of various characters among Sunflower accessions

Traits	DTF	DTM	HD	NOA	AY	FA%	100AW	PY	OA	LA	PA	OY
PH	0.077	0.317*	0.081	-0.027	0.714*	0.082	0.398*	0.086	-0.029	-0.146	0.531*	0.12
DTF		0.351*	-0.268*	0.556*	-0.386*	0.221*	-0.339*	0.104	-0.394*	-0.016	-0.488*	0.394*
DTM			-0.213*	0.099	0.173*	-0.178*	0.162	-0.235*	-0.139	0.131	-0.184*	0.046
HD				-0.167*	0.214*	0.155	0.152	0.127	-0.162*	0.132	0.271*	0.013
NOA					-0.158	-0.126	-0.168	0.410*	-0.146	0.486*	-0.273*	0.085
AY						-0.422*	0.528*	0.264*	-0.088	0.03	0.828*	0.104
FA%							-0.172	-0.267*	-0.046	-0.423*	-0.193*	-0.462*
100 AW								-0.097	0.234*	0.012	0.433*	0.482*
PY									-0.313*	0.151	0.248*	0.097
OA										0.094	-0.108	-0.678*
LA											-0.285*	0.082
PA												0.008

Plant height (PH), days to 50% flowering (DTF), days to maturity (DTM), head diameter(HD), No. of achenes (NOA), achene yield(AY), filled achene percentage (FA%), 100 achene weight (100 AW), oil yield (OY), protein yield (PY), oleic acid(OA), linoleic acid (LA), palmitic acid (PA)

Table 3. Diagonals (bold) are direct effects upper and lower diagonal are indirect effects for achene yield

Trait	P.H	DTF	DTM	HD	NOA	OY	FA%	100 AW	PY	OA	LA	PA
P.H	**0.28**	0.01	-0.01	0.1	0.01	0.01	-0.1	0.21	0.09	0.01	0.00	0.07
DTF	0.1	**0.17**	-0.79	0.01	-0.59	0.00	0.07	0.1	0.04	0.01	0.21	0.21
DTM	0.00	0.01	**0.17**	-0.4	0.01	0.04	0.1	0.00	-0.11	0.11	0.00	0.1
HD	0.09	0.00	0.01	**0.76**	0.03	0.03	-0.79	0.00	0.01	0.02	0.09	-0.03
NOA	0.2	0.01	0.01	0.01	**0.2**	0.01	0.02	-0.56	-0.54	0.00	0.01	0.2
OY	0.00	0.02	-0.54	0.00	0.00	**0.31**	0.00	0.01	0.01	0.07	-0.1	0.18
FA%	-0.2	0.00	-0.06	0.01	0.00	0.12	**0.11**	0.2	0.1	0.00	0.01	0.21
100 AW	-0.5	0.01	-0.09	0.04	0.01	0.02	0.00	**0.16**	0.02	0.1	0.00	0.2
PY	0.05	0.05	0.01	0.00	0.1	0.2	-0.48	-0.2	**0.19**	-0.19	0.21	0.00
OA	-0.49	0.05	0.00	0.01	0.01	0.1	0.01	0.1	0.00	**0.19**	0.1	-0.06
LA	0.00	0.05	-0.02	0.01	0.2	-0.34	0.00	0.00	0.19	0.47	**0.29**	-0.04
PA	0.00	-0.54	0.02	0.01	0.3	0.02	0.01	0.00	0.02	0.09	0.04	**0.2**

Plant height (PH), days to 50% flowering (DTF), days to maturity (DTM), head diameter(HD), No. of achenes (NOA), filled achene percentage (FA%), 100 achene weight (100 AW), oil yield (OY), protein yield (PY), oleic acid(OA), linoleic acid (LA), palmitic acid (PA)

Conclusions

The comparison of correlation coefficients of 13 independent variables against achene yield per plant showed that plant height, head diameter, 100 achene weight, protein yield and palmitic acid had significant positive correlation coupled with the highest direct effects on achene yield. It is suggested that selection of these main traits are good for enhancement of sunflower achene yield.

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