CORRELATION AND PATH CO-EFFICIENT ANALYSIS FOR ACHENE YIELD AND YIELD COMPONENTS IN SUNFLOWER

Furrkh Ilahi, Muhammad Hammad Nadeem Tahir* and Hafeez Ahmad Sadaqat
Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad
*Corresponding author's e-mail: mhammadnadeem@yahoo.com

Twelve sunflower genotypes viz. A-43, A-75, A-88, A-132, A-133, A-185, G-33, G-46, G-51, G-68, G-100 and HBRS-1 were grown in the research field of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, during the year, 2005 following a triplicate randomized complete block design lay out. Variability among these genotypes was assessed for plant height (cm), number of leaves per plant, internodal length (cm), stem diameter at base (mm), head diameter (cm), head type, 100-Achene weight (g), achene weight per head (g) and oil contents (%). Genotypic and phenotypic correlations among these traits and their direct and indirect effects on achene weight per head were estimated. The genotypes were significantly different for all the traits studied. The genotype HBRS-1 had the best performance for most of the characters under discussion. Achene weight per head had positive and significant genotypic and phenotypic correlations with plant height, internodal length and head diameter. The correlations of 100-achene weight with stem diameter and head diameter were also positive and significant at both phenotypic and genotypic levels. Internodal length followed by stem diameter at base and head diameter had the highest direct effects on achene weight per head. 100-achene weight had high indirect effects on achene weight per head via stem diameter and head diameter. Stem diameter at base, head diameter and 100-achene weight can be used as indirect selection criteria for the improvement of achene yield.
Keywords: Sunflower, genetic variability, correlation, path-coefficient analysis, achene yield components

INTRODUCTION

Pakistan has always remained dependent on the import of edible oil to meet its domestic requirements. The per capita consumption of edible oil is around 15 Kg. Total consumption is around 3.00 million tons. Local production is between 0.6-0.8 million tons (Janmohammed, 2008). Pakistan is producing about one third of its edible oil requirements and the rest is met through import against billions of rupees each year.

Around 187.1 million tones of edible oil at a cost of Rs 109 billion was imported during 2007-08, while oil seeds costing Rs 28 billion were also imported during the same period (Altaf, 2009). Substantial amount of our valued foreign exchange is spent on importing edible oil, which not only brings hardship to the people but also burdens the national economy. The locally produced edible oil fulfills only 29% of the domestic requirements. 63% of the local production is contributed by cotton that is basically grown for fibre.

The production of edible oil in the country can be increased by (a) increasing area under oilseed crops, (b) introducing new oilseed crops, and (c) improving the genetic potential of the existing oilseed crops. Area under cultivation cannot be increased due to limited land resources and competition with the other crops in the same season. Therefore, the solution left is the introduction of new oilseed crops and genetic improvement of the existing ones.

Sunflower is an important oilseed crop with a short maturity period (90 to 110 days) and is easily adjustable in our cropping pattern without influencing the cash crops like cotton, rice and wheat. Its seed contains high oil content ranging from 25 to 48% (Weiss, 1983) and is rich in protein i.e. 23 % (Vranceanu *et al.,* 1987). Furthermore, sunflower oil contains fat-soluble vitamins A, B, E and K, well for heart patients. (Evertt *et al.,* 1987; Gossal *et al.,* 1988). For every 100 pounds of sunflower achene, 35% of high protein meal is also produced (Michael and Jeri, 2004). So it can also be used as birdseed and livestock feed etc. (Robert *et al.* 1993). Therefore, it has a great potential to bridge the gap between consumption and production of edible oil in the country.

The soil and climatic conditions of the country are highly favourable for sunflower. It is being cultivated on 1124 thousand acres, producing 696 thousand tons of seed and 264 thousand tons of edible oil (Govt. of Pakistan, 2007-08). 72156 metric tons of sunflower seed is imported (Janmohammed, 2008) which is too much expensive, leading to the increased cost of production and thus pushing the farmers away from its cultivation. Furthermore, imported genotypes have not been developed for ecological conditions of Pakistan, so have adaptability problems like diseases/insect pest. The situation necessitates the development of local hybrids and varieties to reduce the import bills and threats to the local ecology.

Genetic variability is the main tool of plant breeder to start any breeding programme. Presence of genetic variability is assessed as a first step for the development of high yielding and better-adapted varieties/hybrids. Correlation coefficient analysis measures the mutual relationship among various plant characters and determines the component characters on which selection can be based for improvement in yield. Path coefficient analysis is a powerful statistical technique which provides means to quantify the interrelationship of different yield components and also indicates whether the influence is directly reflected in seed yield or takes some other pathway for ultimate effect and also help in partitioning the genetic correlation coefficients into its direct and indirect effects, so that the contribution of each causal variable to the resultant variable can be estimated. The research work presented in the paper was planned to assess the genetic variability in sunflower genotypes for achene yield and its components. This study also aimed at the estimation of association among various plant traits at phenotypic and genotypic levels; and also to find out direct and indirect effects of these traits on achene yield.

MATERIALS AND METHODS

Twelve sunflower genotypes viz. A-43, A-75, A-88, A-132, A-133, A-185, G-33, G-46, G-51, G-68, G-100 and HBRS-1 were sown in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad in 2005. Experiment was laid out following a Randomized Complete Block Design with three replications. Row to row distance was maintained 75 cm and plant to plant 30 cm. All recommended agronomic and cultural operations were followed uniformly for all the genotypes in each replication.

At maturity, ten plants of each genotype were taken randomly from each replication and data were recorded on plant height (cm), stem diameter at base (mm), internodal length (cm), number of leaves per plant, head diameter (cm), achene weight per head (g), 100-achene weights (g) and achene oil contents (%). The data collected were subjected to the analysis of variance following Steel and Torrie (1997) to estimate variability among the genotypes for the traits under study. Genotypic and phenotypic correlation coefficients were estimated among the traits following Kown and Torrie (1964). Direct and indirect effects of various traits on achene weight per head were computed according to the method given by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Presence of genetic variability in the breeding material is a pre-requisite for any breeding programme for crop improvement. The mean squares from analysis of variance (Table 1) indicated highly significant differences among the genotypes for all the traits. This suggests the presence of sufficient genetic variability in the breeding material for the traits under study. Variability for these traits in sunflower has also been reported by many researchers (Sujatha *et al.* 2002; Nehru and Manjunath 2003; Ozer *et al.* 2003; Rao *et al.* 2003). The comparison of mean performance of the genotypes under study (Table 2) revealed that plant height, number of leaves per plant, internodal length, stem diameter at base, head diameter, 100-achene weight, achene weight per head and oil contents ranged from 127.9-254.6 cm, 11-16, 6.27-9.73 cm, 8.47-11.30 cm, 13.90-18.57 cm, 4.57-7.13 g, 40.50-70.10 g and 7.33-43.33 %, respectively. The breeding material used in the present study had better performance for plant height, 100-achene weight, achene weight per head and showed comparable performance for head diameter and oil contents compared to the ranges reported in the literature i.e. 78.76-174.3 cm for plant height (Gurbuz and Arsalan 1993; Hussain *et al.* 1994; Hussain *et al.* 1995), 3.33-5.88 g for 100-achene weight (Hussain *et al.* 1994; Hussain *et al.* 1995), 24.60-42.24 g for achene weight per head (Hussain *et al.* 1994), 8.75-19.62 cm for head

Table 1. Mean squares from the analysis of variance for various plant traits among 12 genotypes of sunflower

SOV	DF	PH	NLP	IL	SD	HD	HAW	AWH	OC
Genotypes	11	37.78**	9.09**	2.07**	2.56**	5.05**	1.69**	191.11**	52.44**
Replications	2	11.00	7.00	0.25	0.78	2.07	0.05	72.36	6.43
Error	22	72.62	2.76	0.09	0.19	0.78	0.07	48.27	2.69

* * = Significant at 0.01 probability level, SOV = Source of variance DF = Degree of freedom, PH = Plant height, NLP = No. of leaves per plant, IL = Internodal length, SD = Stem dia. at base HD = Head diameter, HAW = 100-Achene weight, AWH = Achene weight per head, OC= Oil contents

diameter (Gurbuz and Arsalan 1993; Hussain *et al.* 1994; Hussain *et al.* 1995), 33.20-43.73 % for oil contents (Gurbuz and Arsalan1993; Hussain *et al.* 1995). The variability in the breeding material used in the present study can be exploited for the improvement of sunflower for higher achene yield.

The genotype HBRS-I had the best performance for plant height, stem diameter at base, head diameter, 100-achene weight, achene weight per head and oil content. This genotype also had the highest percentage of droopy type heads. Genotype G-46 also had good results for plant height, internodal length, stem diameter at base, 100-achene weight, and achene weight per head. A-185 and A-132 were also found as good performing genotypes for number of leaves per plant, head diameter and achene weight per head (Table 2). These genotypes can be used as parents in the hybridization programmes for the development of high yielding sunflower hybrids.

Plant height, internodal length and head diameter had positive and significant correlation with achene weight per head at both genotypic and phenotypic levels (Table 3). The correlations of 100-achene weight with stem diameter and head diameter were also positive and significant. Nirmala *et al.* (1999), Ashoke *et al.* (2000), Dagustu (2002), Gill *et al.* (2003), Mahmood

Table 2. Mean values from analysis of variance for various traits in sunflower

Genotypes	PH	NLP	IL	SD	HD	HAW	AWH	OC
A-75	233.9 c	13 bcd	8.60 bcd	11.27 a	15.27 cd	6.16 cd	55.45 bc	41.00 ab
A-132	251.6 ab	11 d	8.83 bc	10.63 abc	16.70 bc	6.50 bc	59.43 abc	39.33 bcd
G-46	254.6 a	11 cd	8.63 bcd	11.13 ab	16.57 bc	7.13 a	65.77 ab	40.00 bcd
A-185	242.2 abc	14 abc	8.60 bcd	10.50 abc	17.23 ab	5.96 d	65.21 ab	38.67 bcd
A-133	238.4 abc	12 cd	9.73 a	10.00 cd	16.70 bc	6.16 cd	70.10 a	41.00 ab
G-51	234.9 bc	15 ab	8.53 bcde	8.67 e	16.80 bc	5.40 e	55.90 bc	40.33 bc
G-100	127.9 e	16 a	6.26 g	9.57 d	15.27 cd	5.43 e	40.50 d	40.00 bcd
A-43	235.7 bc	14 abcd	7.96 ef	10.40 bc	14.33 d	6.06 cd	52.70 bcd	37.67 cd
A-88	202.8 d	11 d	8.13 def	10.33 bcd	15.50 cd	5.90 d	56.37 bc	37.33 d
G-68	240.5 abc	14 abcd	9.00 b	10.00 cd	16.23 bc	6.90 ab	50.66 cd	40.00 bcd
HBRS-1	250.2 abc	13 bcd	7.83 f	11.30 a	18.57 a	7.10 a	62.60 abc	43.33 a
G-33	252.8 a	13 abcd	8.30 cdef	8.47 e	13.90 d	4.56 f	53.27 bc	40.33 bc

PH =Plant height, NLP = No. of leaves per plant, IL = Internodal length, SD = Stem diameter at base, HD = Head diameter, HAW = 100-Achene weight, AWH = Achene weight per head, OC = Oil contents.

Table 3. Genotypic (upper value) and phenotypic (lower value) correlation coefficients among various plant traits in sunflower

Variables	NLP	IL	SD	HD	HAW	AWH
PH	0.617^{*} 0.361	0.795^{*} 0.709^{**}	0.219 0.186	0.281^{*} 0.260	0.343 0.314	0.759^{*} 0.599^{**}
NLP		0.643^{*} 0.438^{*}	0.584^{*} 0.393	0.259 0.028	0.539^{*} 0.362	0.905^{*} 0.328
IL			0.112 0.086	0.274 0.206	0.285 0.284	0.887^{*} 0.515^{*}
SD				0.475 0.343	0.856^{*} 0.743^{**}	0.485 0.303
HD					0.678^{*} 0.559^{**}	0.544^{*} 0.626^{**}
HAW						0.462 0.382

* = Significant at 0.05 probability level, ** = Significant at 0.01 probability level, PH = Plant height
NLP = No. of leaves per plant, IL = Internodal length, SD = Stem dia. at base, HD = Head diameter
HAW = 100-Achene weight, AWH = Achene weight per head

and Mehdi (2003), Nehru and Manjunath (2003), Ozer *et al.* (2003) and Rao *et al.* (2003) have also reported positive and significant correlations of plant height, internodal length, stem diameter at base, head diameter and 100-achene weight with achene weight per head.

Path coefficient analysis (Table 4) revealed that internodal length followed by stem diameter at base and head diameter, respectively had the highest positive direct effects on achene weight per head. The highest indirect effect on achene weight per head was recorded from 100-achene weight via stem diameter, followed by plant height via internodal length. Furthermore, indirect effects of stem diameter and 100-achene weight on achene weight per head via head diameter were also positive and high. Visic (1991), Alvarez *et al.* (1992), Marinkovic (1992), Punia and Gill (1994), Patil *et al.* (1996), Lal *et al.* (1997), Nirmala *et al.* (1997), El-Hosary *et al*. (1999), Ashoke *et al*. (2000) and Tahir *et al.* (2002) have also reported positive direct effect of internodal length followed by stem diameter at base and head diameter on achene weight per head. The results of correlation analysis and path analysis suggest that head diameter, 100-achene weight and stem diameter are the real components of achene yield per plant. Achene yield can be enhanced by improving these plant traits. Furthermore, these traits can also be used as indirect selection criteria for achene yield per plant.

Table 4. Direct (bold diagonal values) and indirect (normal values) effects of various plant traits on achene weight per head in sunflower

Varieties	PH	NLP	IL	SD	HD	HAW	r_g
PH	- 0.031	0.297	0.501	0.137	0.154	- 0.300	0.259
NLP	0.019	- 0.482	0.405	- 0.366	- 0.143	0.471	0.098
IL	- 0.024	0.310	0.630	0.071	0.151	- 0.249	0.095
SD	- 0.007	0.281	0.071	0.627	0.261	- 0.748	0.186
HD	- 0.009	0.125	0.173	0.298	0.550	- 0.593	0.665
HAW	0.011	0.259	0.179	0.536	0.373	- 0.875	0.280

PH = Plant height, NLP = No. of leaves per plant, IL = Internodal length, SD = Stem dia. at base, HD = Head diameter
HAW = 100-Achene weight, AWH = Achene weight per head, r_g = Genotypic correlation co-efficient

CONCLUSION

From the present research, it is concluded that the breeding material used in this study has sufficient genetic variability that can be exploited in further breeding programmes. Furthermore, achene weight per head depends on stem diameter at base, head diameter and 100-achene weight. These characters can be used as indirect selection criteria to improve achene yield.

REFERENCES

Altaf, Z. 2009. Seminar on future of cotton marketing in Kabirwala (Multan). May 14, 2009. Pakistan Agricultural Research Council.

Alvarez, D.P. Luduena and E. Frutos. 1992. Variability and genetic advance in sunflower. Proceedings of the 13th International Sunflower Conference 2: 963-968.

Ashoke, S., S. Mohamed and S. Narayanan. 2000. Character association and path coefficient analysis in sunflower. Crop Res. 20(3): 453-456.

Dagustu, N. 2002. Correlation and path coefficient analysis of seed yield components in sunflower (*Helianthus annuus* L.). Turkish J. Field Crops 7(1): 15-19.

Dewey, D. and K. Lu. 1959. Correlation and path coefficient analysis of creasted wheat grass seed production. Agron. J. 51: 515-518.

EL-Hosary, A., EL-Ahmar and A.E. Kasaby. 1999. Association studies in sunflower. Helia 22: 561-567.

Evertt, N.P., K.E. Robinson and D. Mascarenhas. 1987. Genetic engineering of sunflower (*Helianthus annuus*). Biotechnology 5(1): 1201-1204.

Gill, H.S., R.K. Sheoran, A. Shahid and H. Ahmed. 2003. Correlation for oil yield in sunflower (Helianthus *annuus* L.). Nat. J. Plant Imp. 5(1): 43-46.

Gossal, S.S., L. Vasiljevic and D.S. Brar. 1988. Plant biotechnology and sunflower improvement. Proceedings of 12th International Sunflower Conference, Novisad, Yugoslavia, July 25-29, p.599.

Govt. of Pakistan. 2007-08. Economic Survey of Pakistan. Statistical Supplement. Economic Advisor's Wing, Ministry of Finance, Govt. of Pakistan, Islamabad.

Gurbuz, B. and N. Arsalan. 1993. Research on some characters of synthetic cultivar obtained from inbred sunflower lines resistant to broomrape. *Orobansa dayanikli kendilenmis aycicegi hatlarindan elde edilen sentetik cesidin bazi karakterleri uzerine bir arastirma. Doga, Turk Tarim ve Ormancilik Dergisi* 17(2): 433-442.

Hussain, M.K., M. Ilyas and O.U. Rehman. 1994. Breeding of sunflower for drought tolerance: variability for drought tolerance in sunflower. Sci. Int. 6(3): 251-254.

Hussain, M.K., A. Rehman and O.U. Rehman. 1995. Breeding sunflower for drought tolerance: combining ability and gene action for drought tolerance in sunflower. Sci. Int. 7(2): 173-176.

Janmohammed, A.R. 2008. 2nd International Palm Oil Trade Fair & Seminar 24-26 August, 2008.

Kown, S. and J. Torrie. 1964. Heritability and interrelationship among traits of two soybean populations. Crop Sci. 4:196-198.

Lal, G., V. Bhadoriya and A. Singh. 1997. Genetic association and path analysis in elite lines of sunflower. Crop Res. 13(3): 631-634.

Marinkovic, R. 1992. Path coefficient analysis of some yield components of sunflower. Euphytica 60(93): 201-205.

Mahmood, T. and S.S. Mehdi. 2003. Correlation among S_1 and S_2 progenies of sunflower for seed yield, its components and resistance to Charcoal Rot Disease. Asian J. Plant Sci. 2(11): 844-849.

Michael, B. and S. Jeri. 2004. Sunflower industry profile. Deptt. of Agri. Ecnomics, Kansas State University, Manhattan, USA.

Nehru, S. D. and A. Manjunath. 2003. Correlation and path analysis in sunflower (*Helianthus annuus L*.). Karnataka Agri. Sci. J. 16(1): 39-43.

Nirmala, V., A. Gopalan and D. Sassikumar. 1999. Correlation and path coefficient analysis in sunflower. Agri. J. Madras 86(4): 269-272.

Ozer, H., O. Erdogon and P. Taskin. 2003. Determination of the agronomic performance of some oilseed sunflower hybrids grown under Erzurum ecological conditions. Turk. J. Agri. 27: 199-205.

Patil, B., M. Rudraaradhiya, C. Vijaykumar, H. Basappa and K. Virupakshappa. 1996. Genetic variability in sunflower. J. Oilseed Res. 13(2): 157-161.

Punia, M.S. and H.S. Gill. 1994. Correlations and path coefficient analysis for seed yield traits in sunflower (*Helianthus annuus L.).* Helia 17(20): 7-11.

Rao, N.V., Y.C. Mohan and S.S. Reddy. 2003. Variability and character association in the elite lines of sunflower (*Helianthus annuus L.).* Research-on-Crops (4)1: 104-109.

Robert, L., C. Harry and B. Kaplan. 1993. Sunflower; an American native. Deptt. of Agronomy, University of Missouri, Colombia, USA.

Steel, R.G.D and J.H. Torrie. 1997. Principles and Procedures of Statistics. McGraw Hill Book Co., New York, USA.

Sujatha, H.L., Chikkadevaiah and Nandini. 2002. Genetic variability study in sunflower inbreds. Helia (25)37: 93-99.

Tahir, M.H.N., H.A. Sadaqat and S. Bashir. 2002. Correlation and path coefficient analysis of morphological traits in sunflower populations. Int. J. Agri. Bio. 4(3): 341-343.

Visic, M. 1991. Correlation between eight characters in three sunflower hybrids and path analysis of coefficients. Savremena polyoprivreda 39(3): 27-34.

Vranceanu, A., M. Luros and F. Stoenescu. 1987. A contribution to diversification of CMS sources in sunflower. Helia 9: 21-25.

Weiss, E.A. 1983. Oilseed crops. Longman Publishing Company, London, UK.