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Correlation and path analysis for yield and yield components in sunflower (*Helianthus annus.* L)

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Ten (10) sunflower genotypes were evaluated in a triplicated randomized complete blocked design in field for plant height, stem diameter at base, internodal length, head diameter, number of whorls head^{-1}, achene weight head^{-1}, 100-achene weight, achene oil and protein content. Association among various plant traits and direct and indirect effects of various traits on achene weight head^{-1} were estimated. Correlations of head diameter, 100-achene weight, stem diameter at base, internodal length and oil contents were positive and significant with achene weight head^{-1}. Path analysis showed that direct effects of plant height, head diameter, 100-achene weight and oil contents were positive while direct effects of stem diameter at base, internodal length, number of fertile whorls head^{-1} and protein contents were negative on achene weight head^{-1}. This shows that selection based on head diameter, 100-achene weight, plant height, internodal length and stem diameter at base will be more effective in improving yield.

Key words: Sunflower, correlation coefficient, path coefficient, yield components.

INTRODUCTION

Oil and fat, being the natural carrier of vitamin A and D, are essential part of human diet and are also important source of energy. With the increasing population of the world, the consumption of edible oil has also been increased. Developing countries between 1963 and 2003 revealed large increase in the available consumption of calories from vegetable oils (199%). Only vegetable oil consumption was seen to increase appreciably (105%) in industrial countries over these four decades (Kearney, 2010). The total availability of edible oil in 2008 to 2009 was 2.821 million tons. Domestic production of edible oil stood at 684 thousand tons during 2008 to 2009, which is 24% of the total availability in the country while the remaining 76% was made available through imports (Government of Pakistan, 2011). Increase in the local oil seed production through the evolution of high yielding hybrids/varieties adaptable to our climatic conditions is the only option to save this huge foreign exchange. Oil seed sunflower is the preferred source of oil for domestic consumption and cooking worldwide (Hu et al., 2010). It is considered as an important oil crop in the world nowadays, with an annual production of 20 to 25 M ha worldwide

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(Anandhan et al., 2010). It was introduced to Pakistan during 1960's with a realization of its importance over other oilseed crops. Sunflower oil is considered as premium oil due to its light color, mild flavor, low level of saturated fatty acids and ability to withstand high cooking temperatures. Despite these advantages, it can also be used as birdseed, livestock feed, etc. (Robert et al., 1993). From every 100 pounds of sunflower achene, 40% of oil, 35% of high protein meal and 20 to 25% of by-products are produced (Michael and Jeri, 2004).

Yield is a most complex character and is a polygenic trait involving a number of genes contributing in it and their interaction with environment. It is more desirable that the structure of yield is probed through breeding techniques. It is important to measure the mutual relationship between various plant attributes and determine the component characters, on which selection procedure can be based for direct and indirect genetic improvement of crop yield.

Breeders focus their entire attention in developing sunflower genotypes with higher oil yield. Higher oil yield is an ultimate objective of sunflower researchers as mostly sunflower seed is imported in the form of hybrid seed from outside which is too much expensive, leading to increased cost of production and thus pushing the farmers away from sunflower cultivation.

Yield, a polygenic trait, is influenced by several characters also called yield contributing traits. These components are related among themselves and with yield either positively or negatively. In general, in most of the studies the associations among yield components have been reported to be negatively correlated thereby hindering the rapid progress that could be made. The path coefficient analysis is a standardized partial regression analysis which permits detailed separation of correlation coefficients to measure direct and indirect effects. Thus, an evaluation of different traits and a study of their interrelationships are of great importance. Such interdependence of contributory characters, as well as the characters of economic importance often misleads and thus makes correlation coefficient by and large unreliable during selection (Dewey and Lu, 1959), particularly in crop like sunflower, which is highly cross pollinated and heterozygous and envisages enormous variability in succeeding generation. Earlier in sunflower, Shankar et al. (2006), Arshad et al., (2007) and Hidyatullah et al. (2008) applied path coefficient by partitioning the genotypic correlations into direct and indirect effects of the traits. Moreover, other researchers have used these techniques along with diversity study for investigating genetic parameters (Arshad et al., 2006; Ghaffari, 2004; Sankar et al., 2004). The scientists Ashoke et al. (2000), Lai et al. (1997), Nirmala et al. (1999) and Tahir et al. (2002) also studied positive direct effect of plant height, head diameter and 100-achene weight on achene weight per head.

In the present study, an attempt was made to investigate the correlation and path coefficient analysis in sunflower genotypes. The present study was conducted to evaluate the different genotypes of sunflower produced locally in the country to screen out high yielding types adaptable to different environmental conditions. The objective of the study was to collect information on the association of various achene yield and oil quality traits and also to estimate direct and indirect effects of various traits on achene yield per plant.

MATERIALS AND METHODS

Ten sunflower genotypes viz. G-46, A-185, G-51, G-59, G-100, G-34, A-133 and three checks that is, FH-243, Bemisal-205 and Bemisal-4710, were sown following Randomized Complete Block Design (RCBD) layout with three replications. Row to row distance was maintained 75 cm and plant to plant 30 cm between rows and 30cm between plants within a row was adopted. Two or three seeds were dibbled in each hill to facilitate better emergence and to provide uniform stand of plants. Thinning was attended at 10 to 12 days after sowing to retain one healthy seedling per hill. All other recommended cultural practices were adopted for healthy crop growth during whole season. Optimum fertilizers (120 kg/ha nitrogen, 60 kg/ha phosphorus and potassium each) were applied to each the crop to exploit their potential. After emergence of seedlings, thinning was done to achieve the optimum plant population. At maturity, data were recorded on plant height, stem diameter at base, internodal length, head diameter, number of fertile whorls per head, achene weight per head, 100 achene weight, achene oil and protein contents. Genotypic and phenotypic correlation coefficients were estimated among the traits following the method given by Kown and Torrie (1964). Direct and indirect effects of various traits on achene weight per head were also computed according to the method given by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The results pertaining to genotypic and phenotypic correlation among various traits presented in Table 1 reveal that plant height had significant (P = 0.05-0.01) and positive correlation with stem diameter at base, head diameter and number of fertile whorls per head while significant (P = 0.05) and negative correlation with protein contents at both genotypic and phenotypic level. Razi and Assad (1999) and Anandhan et al. (2010) showed similar results. Positive and significant (P = 0.05-0.01) correlation at both genotypic and phenotypic level was also observed between stem diameter and number of fertile whorl per head. Stem diameter at base and number of fertile whorls per head had significant (P = 0.05-0.01) but negative correlation with protein contents at both genotypic and phenotypic levels. Oil contents showed positive and significant (P= 0.05) correlation with head diameter and number of fertile whorls per head at phenotypic level. Dahiphale and Pawar (1992), Khan et al. (2005) and Mahmood and Mehdi (2003) also found positive and significant correlation of oil contents with head diameter and number of fertile whorls per head.

Achene weight per head showed positive and significant (P = 0.05-0.01) correlation with internodal length at

Table 1. Genotypic and Phenotypic Correlation Matrix. Genotypic (upper value) and phenotypic (lower value) correlation coefficients among various plant traits in sunflower.

Variable	SD	IL	HD	NFWH	HAW	OC	PC	AWH
PH	0.869* 0.826**	0.171 0.158	0.540* 0.481**	0.686* 0.534**	-0.061 -0.067	-0.211 -0.210	-0.764* -0.750*	0.171 0.122
SD		0.193 0.186	-0.335 -0.301	0.749* 0.554**	0.349 0.339	-0.095 -0.094	-0.680* -0.664**	0.500* 0.356
IL			0.459 0.361	0.102 0.108	0.441 0.436"	0.361 0.343	-0.046 -0/049	0.986* 0.762**
HD				0.142 0.144	0.258 0.236	0.519 0.454*	0.335 0.307	0.434 0.464*
NFWH					-0.148 -0.091	0.563 0.456*	-0.715* -0.565**	0.365 0.305
HAW						0.280 0.264	0.333 0.329	0.638 0.553"
OC							0.106 0.102	0.538 0.463*
PC								-0.463 -0.206

*Significant at 0.05 probability level; * significant at 0.01 probability level. PH, Plant height; SD, stem diameter at bas; IL, internodal length; HD, head diameter; NFWH, number of fertile whorls/ head; HA W, 100-achene weight OC, oil contents; PC, protein contents; HAW, achene weigh per head.

Table 2. Path Coeffecient Analysis Table. Direct (bold) and indirect effects of various traits on achene weight per head in sunflower.

Variable	PH	SD	IL	HD	NFWH	HAW	OC	PC	r_g
PH	**12.1045**	-10.359	-0.7755	-2.5264	-1.452	-0.4572	-0.1709	3.80863	0.171
SD	10.5376	**-11.911**	-0.8768	-1.5708	-1.5873	2.60502	-0.0766	3.39082	0.500
IL	2.07535	-2.309	**-4.523**	2.14842	-0.2175	3.29113	0.29148	0.22981	0.986
HD	-6.5381	4.00004	-2.0775	**4.67736**	-0.3012	1.92565	0.41915	-1.671	0.434
NFWH	8.3042	-8.933	-0.4649	0.66564	**-2.1165**	-1.1069	0.4543	3.56273	0.365
HAW	-0.7425	-4.1624	-1.9969	1.20827	0.31427	**7.45439**	0.22647	-1.6635	0.638
OC	-2.5647	1.13171	-1.6364	2.43071	-1.1921	2.09305	**0.80656**	-0.5322	0.538
PC	-9.4536	8.10677	0.20863	1.56883	1.51352	2.48899	0.08617	**-4.982**	-0.463

PH, Plant height; SD, stem diameter at bas; IL, internodal length; HD, head diameter; NFWH, number offertile whorls/ head; HAW, 100-achene weight OC, oil contents; PC, protein contents; r_g , genotypic correlation coefficient.

both genotypic and phenotypic levels. Lai et al. (1997) also reported positive and significant correlation of achene weight per head with internodal length. Positive and significant (P = 0.01) correlation of 100-achene weight with achene weight per head at phenotypic level was found. Ahmad (2001) also reported positive and significant correlation of 100-achene weight with achene weight per head.

Path coefficient analysis (Table 2) revealed that plant height followed by 100-achene weight and head diameter respectively had highest positive direct effect with achene weight per head. Ashokeet al. (2000), Lai et al. (1997), Nirmala et al. (1999) and Tahir et al. (2002) also reported positive direct effect of plant height, head diameter and

100-achene weight on achene weight per head. All the other traits except oil contents had negative direct effects on achene weight per head. The highest indirect effect was shown by stem diameter at base through plant height. It was followed by indirect effect of number of fertile whorls per head via plant height and protein contents via stem diameter at base, respectively.

Correlation of plant height was positive and significant with stem diameter at base, head diameter and number of fertile whorls per head. It is suggested that with increasing plant height, stem diameter at base also increased to support larger heads with more number of fertile per head which will prevent tall plants from lodging. Positive correlation of head diameter and 100-achene weight with achene weight per head at phenotypic level suggests that these characters are true yield components of achene yield in sunflower. Direct effects of plant height, head diameter and 100-achene weight on achene weight per head were also positive. The results indicate that these plant traits could be used as selection criteria to improve achene yield in sunflower.

Conclusion

From the present research, it is concluded that achene weight/ plant depended on plant height, stem diameter at base, head diameter, number of fertile whorls per head and 100-achene weight. It means that selection based on these characters will be more effective in improving yield in sun flower.

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