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Correlation and Path Analysis in Advanced Inbred Lines of Sunflower

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A B S T R A C T

The primary objective in sunflower breeding is to develop cultivars with high yield. Achene yield in sunflower is a complex trait, influenced by various component traits and environmental factors. Understanding the traits interaction among themselves and with the environment is very essential in planning successful crop improvement program. Present investigation "Correlation and path analysis in advanced inbred lines of Sunflower" was carried out during 2017-2018. The study included 117 advanced inbred lines and 4 checks. Correlation study reported highly significant positive association of seed yield per plant with plant height (0.942; 0.933) followed by head diameter (0.852; 0.818), 100 seed weight (0.243; 0.217) and days to 50 % flowering (0.238; 0.219) in sunflower at both phenotypic and genotypic level, respectively. Among the characters studied plant height (0.933; 0.929) had the highest positive direct effect on seed yield per plant followed by volume weight (0.042; 0.046), head diameter (0.024; 0.040) and days to maturity (0.0124; 0.023) at both genotypic and phenotypic level. Therefore direct section for early maturing with tall stature and larger head would be useful in developing high yielding genotypes in sunflower.

Introduction

Sunflower, emerged as an important oilseed crop, a rich source of edible oil (40-52%) having anti-cholesterol properties due to the presence of polyunsaturated fatty acids (55-65% Linoleic acid and 20-30% Oleic acid), which are known to reduce the risk of coronary diseases (Joksimovic *et al.*, 2006). In sunflower, seed yield and oil content are complex traits which are affected by several component traits and environmental factors. Understanding the traits interaction among themselves and with the environment is very essential in planning successful crop improvement program. Correlation study provides an insight on the nature and extent of association between any two pairs of metric characters. From this it would be possible to bring about genetic enhancement in commercially important character like seed yield through indirect selection of component traits. Unlike the correlation coefficient values which measures the extent of relationship, path coefficient splits the correlation coefficient into measures of direct and indirect effects and estimates the direct and indirect contribution of various component traits towards yield. Hence, the correlation coefficient represents the sum total effects (direct or indirect) of all traits to which it is correlated either positively or negatively and hence selection based on this value alone will be time consuming unless the direct effect is very high and operate in the same direction. Hence, the study of direct and indirect effects through the path analysis has gained much importance. It also helps to improve different characters simultaneously. In this direction, a study on correlation and path analysis was conducted for yield and yield component traits in sunflower.

Materials and Methods

The experiment consisted of 117 advanced inbred lines and four checks (DRSF 108, DRSF 113, RSFV 901 and Morden). The experiment was laid out in a simple lattice design with two replications during 2017-2018. Each inbred line was sown in the three meter length of two rows with 10 plants in each row. The inbred lines along with the checks were sown by keeping row to row distance of 60 cm and plant to plant distance of 30 cm for each genotype. The observations on days to 50 per cent flowering, days to maturity, plant height, head diameter, test weight, volume weight, seed yield and oil content were recorded on five randomly selected plants. Genotypic and phenotypic correlation coefficients were calculated using the method given by Johnson *et al.*, (1955). The direct and indirect effects of seven component traits on seed yield per plant were estimated by path coefficient analysis as suggested by Dewey and Lu (1959).

Results and Discussion

Correlation study

Phenotypic and genotypic correlation coefficients are represented in Table 1a and Table 1b. Seed yield per plant had highly significant positive association with plant height (0.942; 0.933) followed by head diameter (0.852; 0.818), 100 seed weight (0.243; 0.217) and days to 50 % flowering (0.238; 0.219) in sunflower at both phenotypic and genotypic level, respectively. Days to maturity (0.152; 0.132) and oil content (0.131; 0.127) exhibited significant positive correlation with seed yield per plant while non significant positive association was observed for volume weight (0.037; 0.036). Hence selection for any of the significantly associated traits under study would be effective in enhancing the achene yield in sunflower. Positive association of plant height with achene yield indicates, more the plant height more would be the number of leaves resulting higher carbon fixation and accumulation of more dry matter. Also, there would be an increase in stem diameter, head diameter, 100 seed weight which are responsible for higher yield (Singh and Chander, 2018). These results are following previous study by Riaz *et al.*, (2019) who reported strongest positive associations of achene yield with number of achene per head followed by 100 achene weight, plant height and head diameter. Similar studies by Kalukhe *et al.,* (2010) showed highly significant positive correlation for days to 50 per cent flowering, plant height, head diameter, test weight, volume weight and oil content except days to 50 per cent flowering for which only positive association was recorded at both genotypic and phenotypic level. Giriraj *et al.,* (1979) reported significant correlation of days to maturity and oil content with oil yield.

Genetic correlation coefficients among the yield attributing traits revealed nature and magnitude of association with each other. In the present study, plant height, head diameter, days to 50 % flowering and 100 seed weight showed strong association among themselves indicating selection for any of these traits will simultaneously improve the other associated trait (Table 1). Hence, selection can be made for late flowering genotypes with tall stature or larger head to obtain genotypes with high achene yield coupled with higher test weight. This favorable selection response for yield and component traits is mainly contributed by tight linkage between the genes controlling component characters or may involve common gene complex governing the component traits. Selection for late maturing types and higher oil content will be effective to get higher yield. It is better not to go for volume weight which was only positively associated with seed yield indicating poor linkage which will break in its further inheritance due to crossing over. As all the studied traits showed positive correlation at genotypic level which indicates the genetic association between the yield and its component traits may be either due to a pleiotropic action of genes, linkage or more likely both.

Days to 50 per cent flowering showed highly significant positive correlation with days to maturity (0.500; 0.580), plant height (0.300; 0.285), head diameter (0.199; 0.180) at both phenotypic and genotypic level indicating the selection for late flowering types alone will be enough to get the lines with late maturity having tall stature and larger head which will automatically contribute for higher yield due to their highly significant association with yield. Genetically, it seemed that the genes contributing for the traits days 50 % flowering, plant height, head diameter, days to maturity and seed yield per plant are located on same chromosome indicating greater association between them.

Days to maturity exhibited highly significant positive correlation with head diameter (0.220; 0.201) at both phenotypic and genotypic level while it is highly significantly positively correlated with plant height at genotypic level only indicating that the positive alleles governing maturity are in close linkage with the positive alleles contributing for plant height and head diameter. Selection for late maturing types will automatically increase plant height and head diameter which accounts for greater seed yield per plant due to their greater association with seed yield per plant. However, days to maturity is negatively correlated with volume weight (-0.240; -0.221) indicating the difficulty in achieving yield improvement by selecting late maturing type genotypes through volume weight.

Plant height exhibited highly significant positive correlation with head diameter (0.896; 0.870) and test weight (0.252; 0.226) at both phenotypic and genotypic level indicating that the genes contributing for higher plant height were in perfect linkage with genes governing for larger heads and higher test weight. Selection for tall genotypes indirectly would select for larger heads and higher test weight, which all together would contribute for greater seed yield per plant. Similar results were reported by Anandhan *et al.,* (2010), Chikkadeviah *et al.,* (2002) and Vanishree *et al.,* (1988). Similarly selection for higher plant height results in higher oil content due to their significant positive correlation (Teklewold *et al.,* 1990; Habib *et al.,* 2007). However plant height was negatively correlated with volume weight at phenotypic and genotypic level.

Anandhan *et al.,* (2010) and Reddy *et al.,* (2014) reported significant positive correlation of volume weight with plant height.

Head diameter recorded highly significant positive correlation with test weight (Sasikala, 2000; Anandhan *et al.,* 2010 and Mogali, 1993) and only positive correlation with oil content (Anandhan *et al.,* 2010). Selection for larger heads will automatically results in greater test weight. Head diameter showed negative correlation with volume weight which found similarity with the study done by Chikkadevaiah *et al.,* (2002). Hence selection for larger head results in lower volume weight which can be compensated by selecting for lines with higher oil content which is positively correlated with both head diameter and volume weight.

Test weight showed significant positive correlation with volume weight at genotypic level but only positive correlation at phenotypic level indicating the influence of environment at phenotypic level. Volume weight showed significant positive correlation with oil content. Hence, selection for higher volume weight is effective to ensure greater test weight as well as oil content. Negative association between test weight and oil content has to be broken by going for selection in large segregating population for test weight and oil content. Manivannan *et al.,* (2005) noticed significant positive association between 100-seed weight and seed volume. Hladni *et al.,* (2011) reported a negative correlation between 1000 seed weight and oil content. Anandhan *et al.,* (2010) reported significant positive correlation of volume weight with oil content.

In any of the oilseed crops the oil content is an ultimate and most important economic product. Breeding for oil content along with higher seed yield is the major objective of any breeding programme in oilseed crops. In this direction the association of oil content with other yield component traits is critical in improving the oil yield. Oil content recorded significant positive correlation with plant height and volume weight and positive correlation with days to 50 per cent flowering and head diameter at both phenotypic and genotypic level. Hence, selection for late flowering types with greater plant height and larger heads improves the oil content. Similar studies by Chikkadevaiah *et al.,* (2002) and Arshad *et al.,* (2007) observed positive association of oil content with plant height, volume weight, head diameter and days to 50 per cent flowering and negative correlation with days to maturity and test weight.

Path analysis

Path coefficient analysis provides a realistic basis for allocation of appropriate weightage to various attributes while designing a pragmatic program for the improvement of yield. It takes into account the cause and effect relationship between the variables which is unique in partitioning the associations into direct and indirect effects through other dependent variables. The path analysis helps to resolve the correlations further and provide a clear picture in which component traits contribute towards dependent variable. In the present investigation, observations for 121 sunflower inbred lines recorded and the estimated phenotypic and genotypic correlations were used to determine direct and indirect effects of yield component traits on seed yield. The results including phenotypic and genotypic path coefficients are presented in Table 2a & 2b.

Among the characters studied plant height (0.933; 0.929) had the highest positive direct effect on seed yield per plant followed by volume weight (0.042; 0.046), head diameter

(0.024 ; 0.040) and days to maturity (0.0124; 0.023) at both genotypic and phenotypic level. While, days to 50 per cent flowering (-0.051; -0.056), test weight (-0.016; -0.024) and oil content (-0.026; -0.026) recorded negative direct effect on seed yield per plant. Khan (2001) reported that first flowering had the highest positive direct effect on seed yield whereas days to 50% flowering negatively affected seed yield via characters like days to 50 per cent maturity and 100-seed weight. Farhatullah *et al.,* (2006) reported maximum direct effect of head diameter and plant height with seed yield followed by test weight, days to maturity, volume weight and oil content. Similarly, Razzaq *et al.,* (2014) reported positive direct effect of days to maturity on seed yield and on the contrary negative direct effect of oil content both at phenotypic and genotypic level.

Maximum positive indirect effects of days to 50 per cent flowering *via* volume weight, days to maturity *via* days to 50 % flowering, plant height *via* head diameter, head diameter *via* plant height, test weight *via* days to 50 % flowering, volume weight *via* test weight and oil content *via* test weight were recorded on seed yield per plant both at genotypic level and phenotypic level, respectively.

Maximum negative indirect effect of days to 50 % flowering *via* days to maturity, days to maturity *via* volume weight, plant height *via* volume weight, head diameter *via* volume weight, test weight *via* head diameter, volume weight *via* days to maturity and oil content *via* volume weight were recorded on seed yield per plant both at genotypic and phenotypic level, respectively.

Similar results by Sheriff *et al.,* (1985) and Syed *et al.,* (2004) revealed maximum direct effect of plant height and indirect effect of plant height *via* days to 50% flowering, days to maturity, head diameter, test weight and oil content on seed yield per plant. Shivaraju *et al.,* (1984) and Arshad *et al.,* (2007) reported that head diameter recorded maximum positive direct effect on yield and also contributed indirectly positively through days to 50 per cent flowering, days to maturity, plant height, test weight, oil content and negatively through volume weight at both phenotypic and genotypic level, respectively.

Negative direct effects of test weight and indirectly positively *via* plant height, oil content and indirectly negatively through days to 50 per cent flowering, days to maturity and head diameter to a limited extent on seed yield per plant were recorded by Alba and Greco (1979) and Lakshman (1983). In most of the studies on sunflower path analysis showed test weight of sunflower having positive direct effect on seed yield per plant. The negative direct effect of test weight on seed yield per plant in the present investigation is limited and it can be compensated by its highly significant positive association with seed yield and also via its indirect positive association with component traits. Hladni *et al.,* (2011) reported that seed oil content had a very strong direct negative effect on seed yield. Hence, selection for seed yield based on oil content was found to be ineffective.

In the present study the residual effect of 0.35 and 0.33 at phenotypic and genotypic level respectively indicated that the component characters under study were responsible for about 65% and 67 % of variability at phenotypic and genotypic level with respective to seed yield per plant.

From the present investigation it was noticed that plant height, volume weight and head diameter recorded maximum direct positive effects on yield and also positive indirect effects for most of the traits.

Table.1 Estimation of phenotypic and genotypic correlation between seed yield and its component characters in sunflower inbred lines

Characters	r	DFF	DMM	PH	HD	TW	VW	OC	YP
Days to 50% flowering	r_p	1.000	0.500**	0.285**	0.18**	-0.126*	-0.165**	0.038	0.219**
	r_g	1.000	0.580**	0.300**	0.199**	-0.153**	-0.177**	0.044	0.238**
Days to maturity	r_p		1.000	0.161*	0.201**	0.098	-0.221**	-0.059	0.132*
	r_g		1.000	0.178**	0.220**	0.116*	-0.240**	-0.063	0.152*
Plant height	r_p			1.000	0.870**	0.226**	-0.005	0.155*	0.933**
	r_g			1.000	0.896**	0.252**	-0.004	0.158*	0.942**
Head diameter	r_p				1.000	0.272**	-0.087	0.095	0.818**
	r_g				1.000	0.296**	-0.091	0.102*	0.852**
Test weight	r_p					1.000	0.103*	-0.130*	0.217**
	r_g					1.000	0.126*	-0.143*	0.243**
Volume weight	r_p						1.000	0.149*	0.036
	r_g						1.000	0.149*	0.037
Oil content	r_p							1.000	0.127*
	r_g							1.000	0.131*
Yield/plant	r_p								1.000
	r_g								1.000

*Significant at 5% level, **Significant at 1%level

r- Correlation coefficient , r_p-Phenotypic correlation coefficient, r_g-Genotypic correlation coefficient.

Table.2a Estimation of phenotypic path co-efficient between seed yield and its component characters in sunflower inbred lines

	DFF	DMM	PH	HD	TW	VW	OC	YP
DFF	**-0.051**	-0.026	-0.015	-0.009	0.006	0.009	-0.002	0.219
DMM	0.006	**0.012**	0.002	0.002	0.001	-0.003	-0.001	0.132
PH	0.266	0.150	**0.933**	0.811	0.211	-0.004	0.145	0.933
HD	0.004	0.005	0.021	**0.024**	0.006	-0.002	0.002	0.818
TW	0.002	-0.002	-0.004	-0.004	**-0.016**	-0.002	0.002	0.217
VW	-0.007	-0.009	0.000	-0.004	0.004	**0.042**	0.006	0.036
OC	-0.001	0.002	-0.004	-0.003	0.003	-0.004	**-0.026**	0.127

Residual effect=0.35

Table.2b Estimation of genotypic path co-efficient between seed yield and its component characters in sunflower inbred lines

	DFF	DMM	PH	HD	TW	VW	OC	YP
DFF	**-0.056**	-0.033	-0.017	-0.011	0.009	0.010	-0.003	0.238
DMM	0.013	**0.023**	0.004	0.005	0.003	-0.006	-0.001	0.152
PH	0.279	0.165	**0.929**	0.832	0.234	-0.004	0.147	0.942
HD	0.008	0.009	0.036	**0.040**	0.012	-0.004	0.004	0.852
TW	0.004	-0.003	-0.006	-0.007	**-0.024**	-0.003	0.003	0.243
VW	-0.008	-0.011	0.000	-0.004	0.006	**0.046**	0.007	0.037
OC	-0.001	0.002	-0.004	-0.003	0.004	-0.004	**-0.026**	0.131

Residual effect=0.33

Partitioning of genotypic correlation between seed yield per plant and its component characters revealed that the direct effects were in general of higher magnitude than that of their indirect effects for all the characters. Therefore these two characters can be used as selection indices to develop high yielding genotypes. However, the present breeding population needs expansion for the variability for oil content to develop the lines with high yielding genotypes coupled with high oil content.

In conclusion**, c**orrelation analysis revealed that the information of positive and negative associations of yield component traits on seed yield could be used to predict the superior cross combinations and to identify traits for ideal plant type and aid in indirect selection to get higher yield. Based on correlation values, it was observed that selection for plant height, head diameter, test weight and days to 50 % flowering in developing high yielding genotypes in sunflower. Path analysis studies reported positive direct effect of plant height, volume weight, head diameter and days to maturity on seed yield per plant. While, days to 50 % flowering, test weight and oil content recorded negative direct effect on seed yield per plant. The direct selection for tall genotypes with larger head coupled with early maturity would be effective in sunflower improvement.

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