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A study on correlation and path analysis for seed yield and yield components in Sun flower [*Helianthus annuus* (L.)]

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Abstract
Correlation and path coefficient analysis in Forty genotypes of sunflower [*Helianthus annuus* (L.)]. Association analysis between seed yield per plant and other fourteen characters revealed that seed yield per plant showed highly significant and positive correlation with head diameter, number of seeds per capitula, number of filled seeds per capitula and 100 seed weight at both genotypic and phenotypic levels. These seed yield per plant also possessed positive association with days to maturity, stem diameter, number of leaves per plant, leaf area at flowering, plant height, oil content and vacant inner diameter. The characters days to 50 per cent flowering, days to initiation of flower and number of unfilled seeds per capitula exhibited negative correlation with seed yield per plant. Path analysis indicated that days to 50 per cent flowering had highest positive direct effect on seed yield per plant followed by number of leaves per plant. The character days to initiation of flower exhibited high negative direct effects, while leaf area at flowering, number of seeds per capitula, plant height, vacant inner diameter showed negative but low direct effects.
Key words: Correlation, Path analysis, sunflower

Introduction

The objectives of any plant breeder include selection from a natural population or from the one developed by him for one or several characters (Simmonds, 1983). Yield is a complex character which can not be improved to a greater extent on its own. Because, it is influenced by a set of other characters known as yield components which are related among themselves and with yield either favorably or unfavorably. In general, in most crops, the associations among yield components are reported to be undesirable thereby hindering the rapid progress that could be made. Hence, it would be necessary to know what kind of relationship exists among and between morphological and yield components and whether a given relationship is a true one. With these objectives the present investigation was carried out to study the correlation between and among yield component traits.

Materials and Methods

The experimental material for present investigation comprised of Forty genotypes of Single headed type Sunflower *(Helianthus annuus* L.*)* obtained from Directorate of Oilseed Research, Rajendranagar, Hyderabad. The material were grown in a randomized block design with three replications during the *summer* season 2011, at Research Farm of Department of Genetics and Plant Breeding, N. M. College of Agriculture, Navsari Agricultural University, Navsari. Five plants were randomly selected in each entry in each replication for recording observation on growth, yield and phonological characters. The seeds were sown at 60×30cm spacing. Genotypic correlation was computed as per method suggested by Weber and Murthy (1952). Path coefficient analysis was carried out as suggested by Wright (1921) and illustrated by Dewey and Lu (1959). The characters which exhibited significant correlation with seed yield were considered for path analysis.

Results and discussion

Correlation

The results of present study, which revealed comparatively higher degree of genotypic correlation coefficients than their phenotypic counterparts in most of the characters, indicated that there was a higher degree of association between two characters at genotypic level. Their phenotypic association was lessened due to the influence of environment. However, in few cases, the phenotypic correlations were slightly higher than their genotypic counterparts, which implied that the non-genetic cause inflated the value of genotypic correlation because of the influence of the environmental factors.

In the present investigation, seed yield per plant was found to be highly significant and positively correlated with head

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diameter, number of seeds per capitula, number of filled seeds per capitula and 100 seed weight at both genotypic and phenotypic level indicating that these attributes were mainly influencing the seed yield in Sunflower. Thus, selection practiced for the improvement in one character will automatically result in the improvement in the other character even though direct selection for improvement has not been made for the yield character. Similar results exhibiting highly significant and positive correlation between seed yield and other traits as obtained in the present investigation were reported by Robert (1970) for head diameter; Chandra and Anand (1977) , Sidhu and Bains (1980) and Vershney and Singh (1978) for plant height, head diameter and 100 seed weight. Lakshmanaiah (1980) for head diameter, 100 seed weight, plant height, stem diameter at both the levels; Chaudhary and Anand (1985) and Lawrence and Shaik (1993) for number of leaves per plant, plant height, maturity, stem and head diameters; Shankar *et al.* (2006) and Yasin and Singh (2010) for number of filled seeds per capitula and head diameter. The seed yield per plant expressed negative correlation with traits, days to 50 per cent flowering and initiation of flower, number of unfilled seeds per capitula in present investigation which suggested scope for breeding high yielding, early flowering, early maturing in future. Similar results in this regard were earlier reported by Khanna (1972) and Fick *et al.* (1974) for number of unfilled seed per capitula; Tyagi SD and Tyagi JP (2010) for 50 per cent flowering and number of unfilled seeds. Days to initial flowering had highly significant and positive correlation with days to initiation of flower at both the genotypic and phenotypic levels, while days to 50 per cent flowering had significant and positive association with days to maturity. Similar results were also reported by Mogali and Virupakshappa (1994), Tahir *et al.* (2002), respectively. Highly significant and positive association of days to 50 per cent flowering with days to maturity indicated that late flowering will result in high seed yield. Initiation of flower exhibited significant and positive correlation with days to maturity at genotypic levels. This result was supported by Ayyasamy *et al.* (1977). Days to maturity showed significant and negative correlation with number of leaves and plant height. This indicated that days to initiation of flower and late maturity are also a good indicator of high yield. This result was supported by Nur (1978).

Stem diameter showed highly significant and positive correlation with leaf area at flowering and vacant inner diameter. This finding was in accordance with those reported by Ayysamy *et al.* (1977). While stem diameter had significant positive association with number of leaves, number of seeds per capitula and number of filled seed per capitula. Rostova and Anashchenko (1984) also found similar correlation of stem diameter with number of seeds and number of filled seeds per capitula; Sheriff *et al.* (1986) for number of leaves and number of seeds per capitulum. Number of leaves were highly significantly and positively associated with plant height and significantly associated with leaf area at flowering. All these associations confirmed the results obtained by Lawrence and Shaik (1993), indicating number of leaves might also be a reliable source for selection.

Plant height showed significant and positive correlations with vacant inner diameter, head diameter, number of seeds per capitula and number of filled seeds per capitula. Similar results were also reported correlation for plant height with head diameter and number of seeds per capitula by Patil *et al.* (1996) and Lawrence and Shaik (1993) and Alba and Greco (1979) for number of seeds per capitula. Therefore, the undesirable association of maturity and plant height with yield suggested a compromise between selection for high yield, dwarfness and earliness.

Head diameter had highly significant and positive correlation with number of seeds per capitula, number of filled and it had negative correlation with number unfilled seeds per capitula and 100 seed weight. Lawrence and Shaik (1993) found similar correlation of head diameter with number of seeds per capitula and 100 seed weight; Khanna (1972) for number of seeds per capitula; Nur (1978) for number of unfilled seeds per capitula; Safavi (2011) for 100 seed weight. Therefore, simultaneous selection of this trait with the other is likely to prove reliable for selection.

Number of seeds per capitula exhibited highly significant and positive correlation with number of filled seeds per capitula and 100 seed weight, while negatively correlated with number of unfilled seed per capitula. All these associations confirmed the results obtained Yasin and Singh (2010). Number of filled seeds per capitula showed significant and negative association with number of unfilled seeds per capitula. D'yakov (1982) supported this result. Therefore, number of seeds and number of filled seeds per capitula were strongly and positively associated with seed yield per plant at both genotypic and phenotypic level.

Oil content showed negative non significant correlation with days to maturity, stem diameter, number of leaves per plant, plant height, number of seeds per capitula, number of filled and unfilled seeds per capitula and 100 seed weight whereas positive association with seed yield,

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days to 50 per cent flowering, days to initiation of flower, leaf area at flowering, vacant inner diameter and head diameter. Fick *et al.* (1974) found similar association with days to 50 per cent flowering, number of unfilled seeds per capitula; Mogali and Virupakshappa (1994) for number of filled seeds per capitula.

If the genetic correlation is high, the two characters can be regarded as being substantially the same and if there are no special circumstances affecting the intensity of selection, it will make little difference in which environment the selection is carried out (Falconer, 1981).

Path analysis-

The highest positive direct effect on seed yield per plant was recorded for days to 50 percent flowering, followed by number of leaves, stem diameter, head diameter, 100 seed weight and number of filled seeds per capitula. Similar results have been reported by Singh and Yadav (1985), Singh *et al.* (1998), and Kholghi *et al.* (2011) for head diameter, number of filled seeds per capitula and 100 seed weight; Ashok *et al.* (2000), Sowmya *et al.* (2010) and Arshad *et al.* (2007) for head diameter; Anuradha *et al.* (2005) for stem diameter, head diameter, and number of filled seed per head.

The negative direct effects of day to initiation of flower with yield per plant was high while that of leaf area at flowering, number of seeds per capitula, plant height, vacant inner diameter were low. Such negative direct effects were also reported by Devi *et al.* (1998) for leaf area index; Arshad *et al.* (2007) for days to flower initation and plant height; Srinivas *et al.* (2010) for leaf area at flowering and plant height. Head diameter showed very high correlation with seed yield per plant which was mainly to its high positive direct and indirect effect via number of seeds per capitula and low indirect effect via days to maturity, plant height, oil content, leaf area at flowering, number of leaves per plant, vacant inner diameter, stem diameter, 100 seed weight and number of filled seeds per capitula. Days to 50 per cent flowering, days to initiation of flower and number of unfilled seed per capitula were negatively correlated with yield. Number of filled seed per capitula also exhibited very high correlation with seed yield per plant which was due to its high direct effect, high indirect effects via number of seeds per capitula and head diameter and low indirect effect via vacant inner diameter, days to maturity and number of leaves per plant. Other indirect effects were negligible.

Though the correlation of number of seeds per capitula with seed yield per plant was highly significant and positive but it had negative direct effect on seed yield per plant. Positive correlation was due to the high negative indirect effect via number of filled seed per capitula and low indirect effect via vacant inner diameter, number of leaves per plant, days to maturity, leaf area at flowering, plant height, stem diameter, head diameter and 100 seed weight. Indirect effects via rest of the characters were negligible.

Highly significant and positive correlation of 100 seed weight with seed yield per plant was due to its low to moderate indirect effect via leaf area at flowering, plant height, days to maturity, stem diameter, number of filled seeds per capitula, number of seeds per capitula and head diameter.

The positive correlation of plant height with seed yield per plant was due to its moderate to high negative indirect effects via stem diameter, head diameter, number of filled seeds per capitula, vacant inner diameter, leaf area at flowering and number of leaves per plant.

Positive significant correlation of number of leaves with seed yield per plant was due to its moderate to high indirect effects via head diameter, number of seeds and filled seeds per capitula, stem diameter, leaf area at flowering, vacant inner diameter and plant height.

Leaf area at flowering had positive correlation with seed yield per plant showing negative indirect and direct effect via all the fourteen characters except number of unfilled seeds per capitula.

In general, indirect effects of all the traits via leaf area at flowering, oil content, days to 50 per cent flowering, days to initiation of flower, vacant inner diameter, days to maturity, number of unfilled seeds per capitula and stem diameter were very small and negligible. Indirect effects of the characters *viz.*, head diameter, number of filled seeds per capitula, 100 seed weight, and number of seeds per capitula were high. Therefore, indirect selection practiced on these characters will results in the improvement of respective characters and ultimately in seed yield.

From the above results, it would be reasonable to suggest that a breeder engaged in the improvement of sunflower yield and oil content should play greater emphasis on the number of seeds per capitula, test weight and total weight of the head.

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Table 1 : Genotypic and phenotypic correlation of seed yield per plant with other characters in 40 genotypes of Sunflower

Characters	R	DFI	DF	DM	PH	SD	HD	NLP	LAF	NSC	NFSC	NUSC	TW	OC	VAC
SY	r_g	-0.179	-0.164	0.071	0.392*	0.242	0.804**	0.331*	0.231	0.759**	0.771**	-0.643**	0.654**	0.075	0.032
	r_p	-0.152	-0.150	0.066	0.381*	0.237	0.746**	0.321	0.215	0.730**	0.746**	-0.576**	0.475**	0.066	0.055
DFI	r_g		0.996**	0.412*	-0.249	0.080	-0.055	-0.309	0.141	-0.109	-0.110	0.083	-0.310	0.125	-0.198
	r_p		0.928**	0.318	-0.213	0.082	-0.014	-0.264	0.110	-0.117	-0.119	0.065	-0.138	0.113	-0.127
DF	r_g			0.374*	-0.221	-0.052	-0.053	-0.310	0.032	-0.128	-0.118	0.070	-0.212	0.104	-0.268
	r_p			0.351	-0.199	-0.018	-0.031	-0.262	0.031	-0.111	-0.107	0.069	-0.169	0.093	-0.190
DM	r_g				-0.344*	0.125	0.180	-0.338*	0.094	0.292	0.279	-0.150	0.070	-0.058	-0.083
	r_p				-0.257	0.122	0.162	-0.277	0.094	0.267	0.253	-0.079	0.058	-0.040	-0.074
PH	r_g					0.278	0.339*	0.891**	0.321	0.344*	0.344*	-0.358*	0.046	-0.073	0.350*
	r_p					0.270	0.327*	0.870**	0.310	0.340*	0.340*	-0.302	0.026	-0.060	0.343*
SD	r_g						0.293	0.347*	0.811**	0.375*	0.357*	-0.204	0.090	-0.067	0.756**
	r_p						0.267	0.327*	0.776**	0.360*	0.342*	-0.175	0.077	-0.068	0.562**
HD	r_g							0.256	0.240	0.824**	0.811**	-0.734**	0.600**	0.014	0.194
	r_p							0.233	0.213	0.768**	0.755**	-0.586**	0.337*	0.029	0.121
NLP	r_g								0.379*	0.287	0.286	-0.316	-0.188	-0.102	0.400*
	r_p								0.361*	0.273	0.275	-0.286	-0.112	-0.096	0.270
LAF	r_g									0.325*	0.303	-0.160	0.046	0.064	0.551**
	r_p									0.309	0.288	-0.133	-0.017	0.073	0.491**
NSC	r_g										0.971**	-0.765**	0.549**	-0.035	0.194
	r_p										0.970**	-0.632**	0.319	-0.029	0.124
NFSC	r_g											-0.807**	0.489**	-0.026	0.144
	r_p											-0.694**	0.295	-0.022	0.104
NUSC	r_g												-0.189	-0.019	-0.003
	r_p												-0.206	0.016	-0.110
TW	r_g													-0.077	-0.022
	r_p													-0.066	0.027
OC	r_g														0.054
	r_p														0.038

DFI= days to flower initiation
DF= days to 50 % flowering
DM=days to maturity
*significant at 0.05
**significant at 0.01

PH=plant height (cm)
SD=stem diameter (cm)
HD= head diameter (cm)

NLP=Number. of leaves per plant
LAF=leaf area at flowering (cm^2)
NSC= Number of seeds per capitula

NFSC= Number of filled seeds per capitula
NUFSC= Number of unfilled seeds per capitula
TW=100 seed weight (g)

SY=seed yield per plant (g)
OC=oil content (%)
VAC=vacant inner diameter (cm)

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Table 2 : Direct and Indirect effects of fourteen causal variable on yield in 40 genotypes of Sunflower

Characters	DFI	DF	DM	PH	SD	HD	NLP	LAF	NSC	NFSC	NUSC	TW	OC	VAC	Correlation coefficient
DFI	-0.713	-0.710	-0.294	0.178	-0.057	0.039	0.220	-0.100	0.040	0.078	-0.059	0.221	-0.089	0.141	-0.179
DF	0.656	0.659	0.246	-0.146	-0.034	-0.035	-0.204	0.021	-0.084	-0.078	0.046	-0.140	0.069	-0.177	-0.164
DM	0.011	0.010	0.027	-0.008	0.003	0.005	-0.009	0.003	0.008	0.008	-0.004	0.002	-0.002	-0.002	0.071
PH	0.062	0.055	0.075	-0.247	-0.069	-0.084	-0.220	-0.079	-0.085	-0.085	0.089	-0.011	0.018	-0.087	0.392*
SD	0.035	-0.023	0.055	0.122	0.439	0.129	0.152	0.356	0.165	0.157	-0.090	0.039	-0.029	0.332	0.242
HD	-0.021	-0.020	0.069	0.131	0.113	0.385	0.099	0.093	0.318	0.313	-0.283	0.231	0.005	0.075	0.804**
NLP	-0.175	-0.175	-0.180	0.504	0.196	0.145	0.566	0.214	0.162	0.162	-0.179	-0.106	-0.058	0.226	0.331*
LAF	-0.015	-0.003	-0.010	-0.033	-0.084	-0.025	-0.039	-0.104	-0.034	-0.032	0.017	-0.005	-0.007	-0.057	0.231
NSC	0.025	0.029	-0.067	-0.078	-0.085	-0.188	-0.065	-0.074	-0.228	-0.221	0.174	-0.125	0.008	-0.044	0.759**
NFSC	-0.040	-0.043	0.101	0.124	0.129	0.293	0.103	0.109	0.350	0.361	-0.291	0.176	-0.010	0.052	0.771**
NUSC	0.001	0.010	-0.002	-0.004	-0.003	-0.009	-0.004	-0.002	-0.009	-0.010	0.012	-0.002	-0.002	0.002	-0.643**
TW	-0.118	-0.081	0.027	0.018	0.034	0.229	-0.072	0.018	0.210	0.187	-0.072	0.382	-0.029	-0.009	0.654**
OC	0.028	0.023	-0.013	-0.016	-0.015	0.003	-0.023	0.014	-0.008	-0.006	-0.004	-0.017	0.222	0.012	0.075
VAC	0.085	0.116	0.036	-0.151	-0.326	-0.084	-0.172	-0.238	-0.084	-0.062	0.001	0.010	-0.023	-0.431	0.032

Residual effect=0.382

DFI= days to flower initiation
DF= days to 50 % flowering
DM=days to maturity
PH=plant height (cm)
SD=stem diameter (cm)
HD= head diameter (cm)
NLP=Number of leaves per plant
LAF=leaf area at flowering (cm^2)
NSC= Number of seeds per capitula
NFSC= Number of filled seeds per capitula
NUFSC= Number of unfilled seeds per capitula
TW=100 seed weight (g)
SY=seed yield per plant (g)
OC=oil content (%)
VAC=vacant inner diameter (cm)