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Research Article

Association and path analysis for seed yield and component characters in sunflower (*Helianthus annuus L.*)

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Abstract
Genotypic and phenotypic correlation among seed yield and eleven component characters were studied in 11 genotypes of sunflower. Association analysis of parents revealed that number of seeds/head, 100-seed weight, head diameter and per cent seed filling had high significant positive correlation with seed yield. Number of seeds/head, 100 seed weight, head diameter and per cent seed filling also had significant positive intercorrelation among themselves. Number of seeds/head, per cent seed filling, hull content and plant height influence the seed yield directly whereas 100-seed weight influenced indirectly through no.of seeds/head and per cent seed filling. Very high indirect contribution for most of the traits is through number of seeds/head. Hence, this trait should be given priority in sunflower seed yield improvement programme.

Key words
Sunflower, correlation, path analysis

Introduction

India is among the largest vegetable oil economies in the world after USA and China and enjoys a distinct position in terms of diversity in annual oilseed crops. Oilseeds form the second largest agricultural commodity after cereals in India accounting for 14 per cent of the country's gross cropped area. It contribute for nearly five per cent of the gross national product and 10 per cent of the value of all agricultural products. Yield is a complex character and influenced by several yield component characters. The knowledge on the association of several characters with yield and interrelationship among these characters is essential for planning a successful plant breeding program. Path coefficient analysis has an advantage over estimation of simple correlation coefficients because it allows partitioning of the correlation coefficients into its components. These components are 1) the path coefficient that measures the direct effect of a predictor variable upon its response variable 2) the indirect effect(s) of a predictor variable on the response variable through other predictor variables (Dewey and Lu, 1959). The purpose of this study was to estimate phenotypic and genotypic correlations and path coefficients of important agronomic traits on seed yield in sunflower to formulate efficient selection strategy.

Material and Methods

Eleven entries comprising five maintainer lines of corresponding CMS lines and six restorer lines were evaluated during *kharif* 2006 at MARS, Dharwad. All the genotypes were sown in a randomized complete block design with three replications, wherein each replication was represented by three rows of 3 m length for each entry. A spacing of 60 cm between rows and 30 cm within a row was provided. All other recommended agronomic practices were followed to raise successful experimental crop. Observations were recorded on ten random plants for days to 50 per cent flowering, days to maturity, number of leaves per plant, plant height, head diameter,100-seed weight, number of seeds per head, per cent seed filling, volume weight, hull content, oil content and seed yield per plant. Correlations among the traits under study were estimated at genotypic and phenotypic levels following the procedure outlined by Al-Jibouri *et al*., (1958). Direct and indirect effects of various plant traits on seed yield per plant were estimated

according to the method given by Dewey and Lu (1959).

Results and Discussion

In general, genotypic correlation coefficients (r_g) were higher in magnitude than phenotypic correlation coefficients (r_p) indicating less influence of environment. The nature and magnitude of correlation among 12 traits in the present study revealed that number of seeds/head exhibited a strong positive association with seed yield (r_g=0.9989, r_p=0.9653) followed by 100 seed weight (r_g=0.9574, r_p=0.8676), head diameter (r_g=0.9321, r_p=0.8266) and per cent seed filling (r_g=0.8517, r_p=0.6747) both at genotypic and phenotypic level (Table 1 and 2). This indicates simultaneous selection for these traits might bring an improvement in seed yield. The earlier studies of Joksimovic *et al*., (1999), Teklewold *et al*. (2000), Dagustu (2002), Khokhar *et al.* (2006), Yasin and Singh (2010) and Sowmya *et al*. (2010) were in agreement with the present finding. The association between hull and oil content was found to be strongly negative (r_g= - 0.753, r_p= - 0.7204) which was confirmed from the past studies of Chikkadevaiah *et al*. (2002). Among yield component characters, per cent seed filling has strong association with number of seeds/head (r_g=0.911, r_p=0.7086) followed by 100-seed weight (r_g=0.6708, r_p=0.6513) and head diameter (r_g=0.8494, r_p=0.6158). Likewise, number of seeds/head is highly associated with head diameter (r_g=0.975, r_p=0.7678) and test weight (r_g=0.9592, r_p=0.9434). Further, plant height and number of leaves/plant were highly correlated (r_g=0.8997, r_p=0.738).

The path analysis (Table 3) showed that the direct effect of number of seeds/head on seed yield was very high and positive (1.787). Thus, the character number of seeds/head which showed high positive correlation and high direct effect with seed yield had a high influence on seed yield. Lawrence and Shaik Mohammad (1993) had also stressed the importance of number of seeds/head for selection. The direct effect of head diameter on seed yield/plant was found to be low in magnitude (0.078) and its indirect effect through number of seeds/head (1.742), per cent seed filling (0.255) and days to maturity (0.260) proved to be chief cause of high positive genotypic correlation with seed yield (0.9321). Hundred seed weight has significant positive correlation with seed yield (0.9574) but the path coefficient analysis revealed a negative direct contribution (-1.136). The significant positive association with seed yield was owing to its indirect contribution mainly through number of seeds/head (1.714) and per cent seed filling (0.266). This is in confirmation with the findings of Vanisree *et al*. (1988) and Velkov (1976). Oil content has negative correlation on seed yield (-0.2444) but its direct effect with seed yield (0.045) was found to be positive due to its indirect contribution through number of seeds/head (-0.368), days to 50 % flowering (-0.240) and hull content (-0.198). Maximum indirect contribution to seed yield was found to be number of seeds/head via head diameter (1.742) and 100-seed weight (1.714). The low residual effect indicates most of the important yield components which are responsible for yield were included in the present analysis.

From the above study it can be concluded that number of seeds/head, 100-seed weight, head diameter, per cent seed filling and days to maturity are the important selection indices for seed yield improvement in sunflower as they had significant positive correlation with seed yield. But 100-seed weight recorded negative direct effect on seed yield hence indirect selection through number of seeds/head and per cent seed filling will be effective for seed yield improvement. Therefore, priority should be given for the number of seeds/head in the selection programme for improvement of seed yield in sunflower.

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Table 1 : Phenotypic correlation coefficients for yield and yield attributing characters in sunflower

	Days to 50 % flowering	Days to maturity	No.of leaves /plant	Head diameter (cm)	Plant height (cm)	100 Seed weight (g)	No.of seeds/ head	Per cent seed filling	Oil content (%)	Hull content (%)	Volume weight (g/100 ml)
Days to maturity	0.8201**										
No.of leaves /plant	-0.2254	-0.0898									
Head diameter (cm)	0.3074	0.4966**	0.1802								
Plant height (cm)	0.099	0.2186	0.738**	0.2059							
100 Seed weight (g)	0.0924	0.3906*	0.2963	0.7526**	0.3264						
No.of seeds/ head	0.2356	0.4316*	0.3142	0.7678**	0.3802*	0.9434**					
Per cent seed filling	0.1897	0.2619	0.5431**	0.6158**	0.5623**	0.6708**	0.7086**				
Oil content (%)	0.4012*	0.3692*	-0.2389	-0.2061	0.1008	-0.2746	-0.2002	-0.217			
Hull content (%)	-0.2844	-0.2641	-0.1316	0.1105	-0.4213*	0.1025	-0.0298	-0.2091	-0.7204**		
Volume weight (g/100 ml)	0.0497	-0.0935	0.2814	-0.4525**	0.4195*	-0.2105	-0.1192	0.0137	0.2062	-0.2476	
Seed yield per plant (g)	0.2615	0.4197*	0.2499	0.8266**	0.2951	0.8676**	0.9653**	0.6747**	-0.2374	0.0193	-0.2044

- Significant at 0.05, ** Significant at 1 %

Table 2 : Genotypic correlation coefficients for yield and yield attributing characters in sunflower

	Days to 50 % flowering	Days to maturity	Number of leaves /plant	Head diameter (cm)	Plant height (cm)	100 Seed weight (g)	Number of seeds/ head	Per cent seed filling	Oil content (%)	Hull content (%)	Volume weight (g/100 ml)
Days to maturity	0.8749**										
Number of leaves /plant	-0.2538	-0.0612									
Head diameter (cm)	0.3263	0.5758**	0.1982								
Plant height (cm)	0.0937	0.2435	0.8997**	0.2472							
100 Seed weight (g)	0.121	0.4165*	0.4323*	1.0571	0.3332						
Numbrer of seeds/ head	0.2555	0.4538**	0.4123*	0.975	0.3886*	0.9592					
Per cent seed filling	0.2354	0.4041*	0.5874**	0.8494**	0.6513**	0.8862	0.911**				
Oil content (%)	0.4184*	0.4084*	-0.241	-0.2534	0.1072	-0.2934	-0.2062	-0.2592			
Hull content (%)	-0.3045	-0.2883	-0.1994	0.124	-0.4591**	0.1018	-0.0438	-0.2511	-0.753**		
Volume weight (g/100 ml)	0.0455	-0.1172	0.4433**	-0.4736**	0.4479	-0.3515*	-0.1863	-0.0571	0.2124	-0.2711	
Seed yield per plant (g)	**0.2728**	**0.4489****	**0.2887**	**0.9321****	**0.3148**	**0.9574****	**0.9989****	**0.8517****	**-0.2444**	**0.0141**	**-0.2045**

Table 3: Direct and indirect effects for seed yield and yield attributing characters in sunflower at genotypic level

	Days to 50 % flowering	Days to maturity	Number of leaves /plant	Head diameter (cm)	Plant height (cm)	100 Seed weight (g)	Number of seeds/ head	Per cent seed filling	Oil content (%)	Hull content (%)	Volume weight (g/100 ml)	Correlation with seed yield **(r)**
Days to 50 % flowering	**-0.574**	-0.502	0.146	-0.187	-0.054	-0.070	-0.147	-0.135	-0.240	0.175	-0.026	**0.2728**
Days to maturity	0.394	**0.451**	-0.028	0.260	0.110	0.188	0.205	0.182	0.184	-0.130	-0.053	**0.4489****
Number of leaves /plant	0.085	0.021	**-0.335**	-0.067	-0.302	-0.145	-0.138	-0.197	0.081	0.067	-0.149	**0.2887**
Head diameter (cm)	0.025	0.045	0.015	**0.078**	0.019	0.082	0.076	0.066	-0.020	0.010	-0.037	**0.9321****
Plant height (cm)	0.013	0.035	0.128	0.035	**0.142**	0.047	0.055	0.093	0.015	-0.065	0.064	**0.3148**
100 Seed weight (g)	-0.137	-0.473	-0.491	-1.200	-0.378	**-1.136**	-1.089	-1.006	0.333	-0.116	0.399	**0.9574****
Number of seeds/ head	0.457	0.811	0.737	1.742	0.694	1.714	**1.787**	1.628	-0.368	-0.078	-0.333	**0.9989****
Per cent seed filling	0.071	0.121	0.176	0.255	0.195	0.266	0.273	**0.300**	-0.078	-0.075	-0.017	**0.8517****
Oil content (%)	0.019	0.018	-0.011	-0.011	0.005	-0.013	-0.009	-0.012	**0.045**	-0.034	0.010	**-0.2444**
Hull content (%)	-0.080	-0.076	-0.053	0.033	-0.121	0.027	-0.012	-0.066	-0.198	**0.263**	-0.071	**0.0141**
Volume weight (g/100 ml)	0.000	-0.001	0.004	-0.004	0.004	-0.003	-0.002	-0.001	0.002	-0.002	**0.009**	**-0.2045**

Residual effect = 0.1005