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Research Note

Correlation and path analysis in sunflower populations

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Abstract:
Correlation and path coefficient analysis was computed on two sunflower populations improved through recurrent selection with pollen selection (C_3G_3) and without pollen selection (C_3). Character association studies in both the populations revealed that the per cent disease index (PDI) at both the stages exhibited non-significant negative association not only with seed yield, but also with head diameter and volume weight. The traits *viz.,* plant height, head diameter and volume weight were found to be significantly associated with the seed yield. The path coefficient analysis for seed yield indicated that PDI at both the stages had negative direct effect on seed yield. Positive direct effect on seed yield was recorded for head diameter, volume weight and plant height. There were no major shifts in correlation and path coefficient values between C_3 and C_3G_3 population.
Key words: Sunflower, population, pollen selection, correlation, path analysis

Sunflower is versatile crop. Its adaptability to a wide range of soil and climatic conditions are the oft-cited phenomenon which makes its cultivation possible during any part of the year in the tropical and sub tropical regions of the country (Reddy and Kumar, 1996). Sunflower is the second major oilseed crop having a potential source of vegetable oil and protein. The crop is grown under diverse agro-production situations, crossing climatic and geographic boundaries. Though the crop is considered as thermo and photo insensitive (Kavi *et al.,* 1994) but the productivity of sunflower in the country is one of the low in the world. There are several biotic and abiotic factors affecting the crop, as it is mainly grown under rainfed conditions. Among biotic factors, Alternaria leaf blight (*Alternaria helianthi*) is one of the important disease of sunflower causing significant yield losses in India and other tropical countries. Alternaria leaf blight is considered as a potential destructive disease in India, particularly in rainy season and may cause yield losses upto 80 per cent under severe epiphytotic conditions (Balasubramanyam and Kolte 1980 and Hiremtah et al., 1990). The disease has been reported from different parts of the world including India and known to cause reduction in flower size, number of seeds per plant, seed yield per plant, seed weight and also the oil content (Reddy and Gupta, 1977, Mirza *et al.*, 1984, Sesha Saila Sree *et al.,* 2004). Over all yield is a complex character which can not be improved 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 favourably or unfavourably.

Various kinds of association among yield attributing traits have been reported in sunflower. The length of development phases before and after flowering were independent of morphological characters (Chervet and Vear, 1990). Seed weight was reported to be positively associated with duration of vegetative phase. Hence, it would be necessary to know what kind of relationship exists between morphological disease and yield components. Therefore, the present study was taken up to study correlation and path analysis involving two populations *viz.*, C_3G_3 (the base population improved through three cycles of recurrent selection with pollen selection) and C_3 (base population improved through three cycles of recurrent selection without pollen selection) in order to improve the population of sunflower.

The base population for populations under study was synthesized by random mating of five genotypes showing relatively less susceptibility to alternaria leaf blight (Acc. Nos. 180-47, 180-48, 875-3, 1229-4 and 1229-17). The base population was improved for resistance through recurrent selection with and without pollen selection. The base population was improved by three cycles of selection and the population improved with pollen selection was considered as C_3G_3 and the population improved without pollen selection was considered as C_3. The C_3 and C_3G_3 populations were grown during *kharif* 2008 for evaluation in two replications. Each population was grown in a plot size of 150 sq. m per replication with a distance of 60 cm between rows and 30 cm between plants. Along all the borders and after every twenty rows susceptible check Morden was planted. All standard agronomic practices except fungicidal spray were followed to raise the crop. Three hundred plants each (150 per replication) in C_3 and C_3G_3 populations were randomly selected for recording observations on disease severity at two stages *viz.*, at flowering and at 15 days after first scoring, seed yield per plant and other characters such as days to flowering of individual plants, plant height, head diameter and volume weight.

Data collected on individual plants of each population was used to compute correlation coefficients as per Weber and Moorthy (1952). Path coefficient analysis was carried out as suggested by Wright (1921) and illustrated by Dewey and Lu (1959).

The phenotypic correlation coefficients between seven quantitative characters in C_3 and C_3G_3 populations are presented in Table 1. In both the populations, head diameter (0.846, 0.871) exhibited highly significant positive association with seed yield followed by plant height (0.583, 0.521) and volume weight (0.320, 0.353). Association of seed yield with days to flowering in both the populations was positive but highly significant only in C_3G_3 population (0.313). In general, PDI at both stages showed negative association with seed yield in both the populations. But significant association was recorded between PDI at 15 days after flowering and seed yield only in C_3 population (-0.181).

Association of days to flowering with plant height (0.368, 0.671), head diameter (0.146, 0.372), PDI at flowering (0.309, 0.339) and PDI at 15 days after flowering (0.330, 0.248) was highly significant in both the populations. However, the association of days to flowering with volume weight was positive and significant in C_3G_3 (0.205), but showed negative significant association in C_3 population (-0.167).

Plant height exhibited highly significant positive association with head diameter (0.583, 0.447) and volume weight (0.378, 0.340) in both C_3 and C_3G_3 populations. The association of plant height with PDI at flowering (0.309) and PDI at 15 days after flowering (0.240) was highly significant only in C_3G_3 population, however, it was not significant in C_3 population. In C_3 population, head diameter exhibited highly significant positive association with volume weight (0.224), where as in C_3G_3 population the association was positive and significant (0.163). Head diameter exhibited negative but non significant association with PDI at 15 days after flowering in both the populations. Highly significant positive association of PDI at flowering with PDI at 15 days after flowering (0.788, 0.817) was recorded in both the populations. In general, PDI at flowering and PDI at 15 days after flowering showed negative association with volume weight.

In biological sciences, one usually encounters a group of variables which are correlated due to complex interactions that are uncontrolled and obscured (Wright, 1921). The degree of association among such variables can be determined through correlation analysis. Correlation between characters signify the importance of such genetic causes as pleiotropic action of genes linkage, improvement brought by selection through related characters and natural selection (Ginzburg and Nikoro, 1933 and Harlan, 1939). Seed yield is combination of many characters, which is polygenic in nature and difficult to make direct selection. It is therefore, desirable to attempt to understand the interrelationships of such a complex trait as seed yield with its less complex but associated component traits. The nature and degree of character association in any crop plant may be understood by studying segregating populations/generation, germplasm lines *etc.* In the present investigation, correlation between characters was studied in two populations improved for resistance to Alternaria leaf blight. In both the populations, plant height, head diameter and volume weight recorded significant positive association with seed yield. Similar association was reported for these traits by Vanisree *et al.* (1988), Singh and Labana (1990), Chaudhary and Anand (1993), Patil *et al.* (1996), Mahender *et al.* (1998) and Rao *et al.* (2003). The results indicated that selection for tall plants with larger head and seeds would result in higher seed yield. Days to flowering also recorded positive association with seed yield. However, the values were high and significant only in C_3G_3 population. In general, the PDI at both the stages recorded negative association not only with seed yield but also with head diameter and volume weight. However, the values were non significant. Similar negative but significant association between disease and seed yield per plant was also reported earlier by Baskaran and Kandaswamy (1978), Balasubramanyam and Kolte (1980), Allen *et al.* (1983), Carson (1985), Hiremath *et al.* (1990) and Shobha Rani (2003). It was also observed in the present study that the important seed yield components like volume weight and head diameter were negatively associated with PDI. Therefore, the selection against PDI resulted in higher values of head diameter and volume weight. The occurrence of disease leads to reduction in volume weight and head diameter. This reduction is mainly because of reduction in active leaf area and current photosynthesis during seed filling stage (Siddique and Brown, 1977; Shabana, 2000, Shobha Rani and Ravikumar, 2002). The disease is severe only after flowering and seed filling stages and current photosynthesis is important for seed filling in sunflower. However, PDI at both the stages showed positive association with plant height and days to flowering. The results are contradictory to earlier studies (Balasubramanyam and Kolte, 1980 and Nagaraju *et al.*, 1994). The disease at flowering is positively correlated with disease at 15 days after flowering. The study on correlation indicated more or less similar associations between seed yield, yield components and disease characteristics and there were no major shifts in character association in two populations. Although, these two populations were developed using different methods, the base population was same for both the populations.

Path coefficient analysis was carried out at phenotypic level for both the populations separately, taking seed yield as dependent character and the others as independent characters. The results obtained for path analysis in C_3 and C_3G_3 populations are presented in Table 2. In both C_3 and C_3G_3 populations, the characters *viz.*, head diameter (0.764, 0.792) recorded the highest positive direct effect on seed yield followed by plant height (0.125, 0.239) and volume weight (0.111, 0.124). On the other hand, days to flowering (-0.075, -0.156), PDI at flowering (-0.003, -0.009) and PDI at 15 days after flowering (-0.116, -0.027) showed negative direct effect on seed yield in both C_3 and C_3G_3 populations. However, the values were not very high. Both the populations showed similar trend for direct effects.

In both the populations, the direct effect of days to flowering was negative but the correlation with seed yield was positive. Days to flowering had high positive indirect influence on seed yield through head diameter (0.111, 0.294) and plant height (0.046, 0.059). The trait, days to flowering was contributing negatively to seed yield through PDI at 15 days after flowering in both C_3 and C_3G_3 populations (-0.038, -0.007). Plant height not only had positive direct effect on seed yield in both the populations but also exhibited positive indirect effect on seed yield through head diameter (0.445, 0.354) in both populations. Plant height had negative indirect effect through days to flowering (-0.028, -0.105) in both the populations.

Head diameter mainly contributed through direct effect in both the populations. Volume weight not only contributed through direct effect, its contribution to seed yield through head diameter (0.124, 0.178) was high followed by plant height (0.047, 0.081) in both the populations.

PDI at flowering, in both C_3 and C_3G_3 populations, had negative indirect effect on seed yield through PDI at 15 days after flowering (-0.091, -0.022). The PDI at flowering had positive indirect influence on seed yield through head diameter (0.058) in C_3 population whereas it was through plant height (0.074) in C_3G_3 population. In general, PDI at flowering and PDI at 15 days after flowering had negative indirect effects through important yield components such as volume weight, head diameter and days to flowering in both the populations. The indirect effect of PDI at flowering in both populations through PDI at 15 days after flowering (-0.091, -0.023) was higher than its direct effect whereas PDI at 15 days after flowering mainly contributed through direct effects in C_3 population, followed by indirect effect through days to flowering (-0.025). However in C_3G_3 population, negative indirect effect of PDI at 15 days after flowering through head diameter (-0.088) was higher than its direct effect. The PDI at both the stages showed positive indirect effect through plant height in both the populations. In general, there were not major shifts either in the direct effects or indirect effects of various characters studied including PDI at two stages on seed yield in C_3 and C_3G_3 populations.

Although the nature and degree of association among various characters can be estimated by correlation analysis, determining the direct effect of one character on another along each separate path or indirectly via others is worthwhile. Path analysis, a biometrical technique developed by Wright (1921) and later elaborated by Dewey and Lu (1957) provides such information. If correlation between a dependent and an independent character arises due to the direct effect of the later, it reflects the true relationship between the two. Selection can therefore be done for the independent character to improve the dependent character (Adefris *et al.*, 2000). In this study, in both the populations, three out of six characters *viz.*, plant height, head diameter and volume weight had direct positive effect on seed yield. Selection for any of these independent traits leads to improve the population for seed yield. Disease incidence at flowering stage is considered as the most critical stage for seed filling. Disease incidence at peak flowering period leads to reduction in active leaf area and current photosynthesis (Siddique and Brown, 1977; Shabana, 2000 and Shobha Rani and Ravikumar, 2002). Disease values at flowering and 15 days after flowering had negative direct effect on seed yield. The head diameter exhibited high positive direct effect than any other traits and PDI at flowering had high negative direct effect on seed yield. There were no major shifts in direct as well as indirect effects of the traits on seed yield between two populations.

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Table 1. Phenotypic correlation coefficients for seven quantitative traits in C_3 and C_3G_3 populations in sunflower

Character	Population	Plant height (cm)	Head diameter (cm)	PDI at flowering	PDI at 15 days after flowering	Volume weight (g)	Seed yield per plant (g)
Days to flowering	C_3	0.368**	0.146*	0.309**	0.330**	-0.167*	0.025
	C_3G_3	0.671**	0.372**	0.339**	0.248**	0.205**	0.313**
Plant height (cm)	C_3		0.583**	0.120	0.007	0.378**	0.583**
	C_3G_3		0.447**	0.309**	0.240**	0.340**	0.521**
Head diameter (cm)	C_3			0.076	-0.020	0.163*	0.846**
	C_3G_3			-0.015	-0.111	0.224**	0.871**
PDI at flowering	C_3				0.788**	-0.134	-0.059
	C_3G_3				0.817**	-0.025	-0.026
PDI at 15 days after flowering	C_3					-0.213**	-0.181*
	C_3G_3					-0.096	-0.116
Volume weight (g)	C_3						0.320**
	C_3G_3						0.353**

** Significance at 1 per cent level
* Significance at 5 per cent level

C_3 : Three cycle of improvement without pollen selection
C_3G_3 : Three cycle of improvement with pollen selection

Table 2. Phenotypic path-analysis for seed yield in C_3 and C_3G_3 populations in sunflower

Character	Population	Days to flowering	Plant height (cm)	Head diameter (cm)	Volume weight (g/100 ml)	PDI at flowering	PDI at 15 days after flowering	Correlation values with seed yield
Days to flowering	C_3	-0.075	0.046	0.111	-0.019	-0.001	-0.038	0.025
	C_3G_3	-0.156	0.059	0.294	0.025	-0.003	-0.007	0.313**
Plant height (cm)	C_3	-0.028	0.125	0.445	0.042	0.000	-0.001	0.583**
	C_3G_3	-0.105	0.239	0.354	0.042	-0.003	-0.007	0.521**
Head diameter (cm)	C_3	-0.011	0.073	0.764	0.018	0.000	0.002	0.846**
	C_3G_3	-0.058	0.107	0.792	0.028	0.000	0.003	0.871**
Volume weight (g/100 ml)	C_3	0.013	0.047	0.124	0.111	0.000	0.025	0.320**
	C_3G_3	-0.032	0.081	0.178	0.124	0.000	0.003	0.353**
PDI at flowering	C_3	-0.023	0.015	0.058	-0.015	-0.003	-0.091	-0.059
	C_3G_3	-0.053	0.074	-0.012	-0.003	-0.009	-0.022	-0.026
PDI at 15 days after flowering	C_3	-0.025	0.001	-0.015	-0.024	-0.002	-0.116	-0.181*
	C_3G_3	-0.039	0.057	-0.088	-0.012	-0.007	-0.027	-0.116

C_3 : Three cycle of improvement without pollen selection
C_3G_3 : Three cycle of improvement with pollen selection
*,** significant at 5 and 1 % level respectively