

Genetic Association and Path Analysis for Oil Yield in Sunflower (*Helianthus annuus* L.)

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ABSTRACT

The association of seven plant traits of 104 sunflower genotypes including 14 lines, 6 testers and their 84 cross combinations were studied to evaluate the genetic association between flowering traits, maturity, plant height and oil content and oil yield. Significant positive correlation between days to maturity, plant height and oil content on one side and oil yield on the other were seen. Days to flower initiation and days to flower completion were negatively correlated with oil yield. Genotypic path analysis revealed that days to flower completion, days to maturity and oil content had positive direct effect on oil yield whereas days to flower initiation, flowering period and plant height has negative direct effects on oil yield.

Key Words: Sunflower; Genotypic correlation; Path analysis; Flowering period; Oil yield

INTRODUCTION

Sunflower breeders focus their entire attention in developing sunflower genotypes with higher oil yield. Higher oil yield is an ultimate objective of sunflower researchers. Oil yield is affected by many other plant characteristics. Plant traits like days to flower initiation, days to flower completion, flowering period, days to maturity, plant height and oil content are very important in connection with oil yield. Earlier Fick *et al.* (1974), Skoric *et al.* (1974), Green (1980) and Joksimovic *et al.* (1999) used simple correlation analysis to study the relationships between oil yield on one side and the other sunflower plant traits on the other side. Simple correlation analysis does not depict the clear picture of mutual relationships among the plant traits.

The path coefficient analysis being a more precise method partitions the direct and indirect effects of independent variables on the dependent variable. So the path analysis explains the clear impact of independent variables on the dependent one. This method has been extensively used by the sunflower researchers (Lakshimanrao *et al.*, 1985; Marinkovic, 1992; Punia & Gill, 1994; Joksimovic *et al.*, 1999).

We studied genetic association between flowering traits, maturity, plant height and oil content on one side and oil yield on the other. We also studied direct and indirect effects of these plant traits on oil yield.

MATERIAL AND METHODS

The experimental material comprised of one hundred and four sunflower genotypes including fourteen lines, six

testers and their eighty four cross combinations. The experiment was conducted at Oilseeds Research Institute, AARI and Faisalabad, Pakistan during Spring 2001. The F₀ seed of 84 crosses along with their 20 parents were planted in a randomized complete block design with two replications. The experimental unit consisted of single row plot of 4.60 m length with plant to plant and row to row distances of 23 and 60 cm, respectively. All other standard practices were applied to the crop.

The data were recorded on ten randomly selected plants of each entry of each replication for days to flower initiation, days to flower completion, flowering period, days to maturity, plant height, oil content and oil yield. The data collected for aforesaid plant traits were statistically analyzed for variance and covariance using the method given by Steel and Torrie (1980). Phenotypic and genotypic correlation coefficients were calculated utilizing the procedure described by Kwon and Torrie (1964). Path analysis was studied according to the method explained by Dewey and Lu (1957). Sunflower researchers like Ivanov *et al.* (1980), Lakshimanrao *et al.* (1985) Marinkovic *et al.* (1992) Punia and Gill (1994) etc., extensively used this method. Oil yield was kept as resultant variable and other characters as causal variables.

RESULTS AND DISCUSSION

Analysis of variance (Table I) indicated highly significant differences among sunflower genotypes for days to flower initiation, days to flower completion, flowering period, days to maturity, plant height, oil content and oil yield.

Correlation among the traits may result from the

pleiotropy or the genetic association among the characters. Genotypic and phenotypic correlation coefficients between oil yield and its components are presented in Table II. From the breeder's point of view, the type of association of oil yield with flowering traits, maturity, plant height and oil content is of permanent importance. The genotypic correlations were generally higher than their corresponding phenotypic correlations. The lower values of phenotypic correlations may be attributed to lower modifying effect of environment on the association of characters at the gene level (Mamun-Hossain & Joarder, 1987).

The data presented in Table II showed that correlation between days to flower initiation and oil yield was negative. The correlation is non-significant at genotypic level but highly significant at phenotypic level. This observation is in accordance with the findings of Ashok *et al.* (2000) and Khan (2001), who reported that days to 50% flowering were negatively correlated with yield.

Days to flower initiation also showed negative genotypic and phenotypic association with plant height and oil content. However days to flower initiation displayed significantly positive correlation with days to flower completion, flowering period and days to maturity both at genotypic and phenotypic levels.

Days to flower completion were noticed to be negatively correlated with oil content and oil yield at both phenotypic and genotypic levels. Flowering period exhibited negative and non-significant genotypic correlation with oil content and oil yield. It is evident from this association that decrease in flowering period may increase

oil content and oil yield ultimately.

The number of days to maturity was positively and significantly correlated with oil yield at phenotypic and genotypic levels (Table II). Similar results have been reported by Teklewold *et al.* (2000). Plant height exhibited positive and significant genetic association with oil content and oil yield, which is in agreement with the earlier findings of Teklewold *et al.* (2000). The correlation coefficient of oil content with plant height and oil yield was positive and significant both at genotypic and phenotypic levels (Table II). Teklewold *et al.* (2000) and Patil *et al.* (1996) also reported similar results in their respective studies.

Path analysis was employed to establish the intensity of independent variables (flowering traits, maturity, plant height & oil content) on the dependent one i.e., oil yield. The analysis is helpful to partition the direct and indirect effects of individual traits on oil yield. This analysis also helps breeders to identify the characters that could be used as selection criteria in sunflower breeding programme.

The direct effect of days to flower initiation on oil yield was negative (-3.116) (Table III).

The indirect effects via days to flower completion (8.721), days to maturity (0.012) and plant height (0.498) were positive. However the indirect effects through flowering period (-1.885) and oil content (-4.577) were negative.

The results pertaining to Table III revealed that the direct effect of days to flower completion on oil yield (9.340) was masked by the negative indirect effects of days to flower initiation (-2.909), flowering period (-2.427), plant

Table I. Analysis of variance for flowering traits, maturity, plant height and oil yield in sunflower (*Helianthus annuus* L.)

Sources of variation	d.f	Mean squares						
		Days to flower initiation	Days to flower completion	Flowering period	Days to maturity	Plant height	Oil content	Oil yield
Replication	1	3.77*	7.31*	0.58 ^{ns}	7.31*	3228.8**	4.69 ^{ns}	353236*
Genotypes	103	4.42**	12.81**	3.57**	4.88**	646.9**	9.99**	243271**
Error	103	0.68	1.27	0.56	1.44	67.6	3.81	54711

*, ** significant at 5% and 1% probability levels, respectively; ns = non-significant

Table II. Estimates of genotypic and phenotypic correlation coefficients among flowering traits, plant height and oil yield in sunflower (*Helianthus annuus* L.)

Traits		Days to flower completion	Flowering period	Days to maturity	Plant height	Oil content	Oil yield
Days to flower initiation	r _G	0.934*	0.713*	0.324*	-0.160	-0.810	-0.349
	r _P	0.907**	0.606**	0.396**	-0.083	-0.530**	-0.249**
Days to flower completion	r _G		0.917*	0.368*	0.035*	-0.730	-0.218
	r _P		0.884**	0.431**	0.083	-0.480**	-0.131
Flowering period	r _G			0.359*	0.248*	-0.526	-0.037
	r _P			0.375**	0.250**	-0.319**	0.028
Days to maturity	r _G				0.417*	0.046	0.450*
	r _P				0.413**	0.192**	0.443**
Plant height	r _G					0.670*	0.859**
	r _P					0.597**	0.787**
Oil content	r _G						0.661*
	r _P						0.655**

*, ** significant at 5% and 1% probability levels, respectively

Table III. Direct and indirect effects of flowering traits, maturity, plant height and oil content on oil yield in sunflower (*Helianthus annuus* L.)

Traits	Direct effects	Indirect effects via					Total direct and indirect effects (genotypic correlation with oil yield)
		Days to flower initiation	Days to flower completion	Flowering period	Days to maturity	Plant height	
Days to flower initiation	-3.116	-	8.721	-1.885	0.012	0.498	-0.349
Days to flower completion	9.340	-2.909	-	-2.427	0.013	-0.111	-0.218
Flowering period	-2.644	-2.223	8.563	-	0.013	-0.772	-0.037
Days to maturity	0.036	-1.011	3.438	-0.949	-	-1.299	0.450
Plant height	-3.115	0.498	0.339	-0.656	0.015	-	0.859
Oil content	5.649	2.524	-6.821	1.392	0.002	-2.086	0.661

height (-0.111) and oil content (-4.126). Flowering period exhibited negative direct effect on oil yield (-2.644). The indirect effects via days to flower initiation, plant height and oil content were also negative, whereas the indirect effects via days to flower completion and days to maturity were found positive.

The direct effect of days to maturity on sunflower oil yield was low and positive (0.036), which was masked by the negative indirect effects of days to flower initiation (-1.011), flowering period (-0.949) and plant height (-1.299). However its indirect effects on sunflower oil yield via days to flower completion and oil content were positive, 3.438 and 0.235, respectively. Plant height exhibited negative direct effect (-3.115) on sunflower oil yield. The corresponding correlation coefficient was positive and highly significant (0.787).

The analysis revealed that the negative direct effect of plant height on oil yield was expressed through indirect effect of flowering period (-0.656). The total positive effect of plant height on oil yield was a result of positive indirect effects of days to flower initiation (0.498), days to flower completion (0.332), days to maturity (0.015) and oil content (3.784).

The highly positive direct effect of oil content (5.649) on sunflower oil yield was masked by the negative indirect effects of days to flower completion (-6.821) and plant height (-2.086). The indirect effects through days to flower initiation (2.524), flowering period (1.392) and days to maturity (0.002) were positive towards oil yield.

The highest indirect effects of days to flower initiation, flowering period and days to maturity with values of 8.721, 8.563 and 3.438, respectively were realized via days to flower completion. However the highest indirect effects of plant height (3.784) and oil content (2.524) were realized via oil content and days to flower initiation, respectively.

The correlation coefficient values of six independent variables showed significant differences against dependent variable. The independent variables exhibited comparable difference among their direct effects on dependent one. The path analysis showed that days to flower completion followed by oil content and plant height had the highest positive direct effect on oil yield. It is, therefore, concluded that these traits can be used for improvement of oil yield and assessment of sunflower breeding materials.

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