

RESEARCH ARTICLE

Genetic Variability, Path Coefficient, and Multivariate Analysis of Seed Yield and its Associated Traits in Sunflower (*Helianthus annuus* L.)

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ABSTRACT

A total of seventy-three sunflower genotypes were used for studying the variability parameters. The analysis of variance revealed significant differences among genotypes for all eight quantitative characters. Among the germplasm entries, high PCV and GCV were observed for head diameter and hundred seed weight. Present experiment revealed the phenotypic coefficient of variance was noticeably greater than the genotypic coefficient of variance, demonstrating the importance of environmental influences on the traits studied. Similarly, strong heritability and high genetic advance as a percentage of the mean were found for plant height, head diameter, hundred seed weight and seed yield per plant. Path coefficient analysis showed days to maturity, head diameter, hundred seed weight and oil content had a direct positive effect on seed yield per plant. Divergence analysis using principal component analysis (PCA) has been performed to effective determination of genetically distant parents, which could be used for hybridization programme. The PCA analysis generated 8 PCs and out of which, 3 PCs had more than one eigen value, cumulatively showing about 73.85 % of the total variation. The Biplot of the first two PCs shows the variation among individuals and the relation between traits studied.

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INTRODUCTION

Sunflower (*Helianthus annuus* L) is ranked fourth and the most crucial oilseed crop in the world after soybean, oil palm, rapeseed, and mustard. Sunflowers have become an essential and crucial oilseed crop in India due to their 30% contribution to the domestic edible oil yield, better adaptability, greater yield potential, high seed multiplication ratio, shorter crop duration, easier and cheaper cultivation. The sunflower seed is a rich source of protein, Vitamin E,

and vital fatty acids (Neelima *et.al.*, 2016). Further, unique characteristics such as light-coloured oil with mild flavour, low levels of saturated fatty acids, and the ability to withstand high cooking temperatures make sunflower oil a premier-quality oil for cooking and culinary purposes (Deshmuk *et al.*, 2016).

Sunflower crop improvement emphasizes the generation of new, high-yielding heterotic hybrids, which can be achieved by utilizing heterotic vigour

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available in genetically dissimilar parental lines (Shamshad *et al.*, 2014). Utilizing the variation present in the population is the chief criterion for any crop improvement programme. To obtain elite germplasm for use in successive breeding programmes, phenotypic selection for desirable traits with high genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), high heritability, and high genetic advance is required. Selection based on yield is highly uncertain because it is complex, polygenic, and strongly influenced by environmental factors. For any crop to be improved, understanding the relationship between yield and other attributes is essential.

Divergence analysis with principal component analysis has been shown to be advantageous for determining which genetically distant parents should be used for hybridization. The goal of sunflower breeding is to produce hybrids or cultivars with superior yields, high oil content, and better oil quality. To achieve this, the breeder must select parents with the highest genetic diversity and combining ability. Sunflower germplasm diversity is often investigated to determine crop variability, assess germplasm for breeding programmes, or identify variability in morphological and agronomic features (Vivek *et al.*, 2023).

MATERIALS AND METHODS

The current study was conducted at the Department of Oilseeds, Tamil Nadu Agricultural University, Coimbatore, to characterize 66 sunflower genotypes and 7 checks. The evaluation and characterization of the genotypes were carried out in an augmented block design. Each entry was sown in two rows (3m length)

with a spacing of 60cm x 30cm. All the recommended practices for better crop production were followed. Five plants were tagged from all entries to record biometric observations. The mean of five plants from every entry was used for statistical analysis. Eight yield contributing traits *viz.*, days to fifty percent flowering, days to maturity, plant height, head diameter, hundred seed weight, volume weight/100 ml of seed, oil content and seed yield per plant were recorded for the estimation of mean, range, ANOVA, variability parameters, and path analysis which was done by the TNAU STAT software program (Manivannan, 2014). The classification for PCV and GCV was adopted from Sivasubramanian and Menon (1973), while that for heritability and genetic advance was adopted from Johnson *et al.* (1955). To assess genetic diversity among lines, principal component analysis (PCA) (Hotelling, 1936) was performed; statistical analyses were conducted in RStudio.

RESULTS AND DISCUSSION

Analysis of variance was used to determine whether the collected data from all 66 genotypes were significant for all the attributes examined in this study. Therefore, it was also taken into account for the estimate of genetic advance, heritability, and genotypic and phenotypic variance. Table 1 provides estimates for the mean, range, standard deviation, standard error, and coefficient of variation.

Variability studies: Among the germplasm entries, high PCV and GCV were observed for head diameter (29.33 and 28.93) and hundred-seed weight (30.19 and 28.67), respectively (Table 2). Similar findings were reported by Rani *et al.* (2017) and

Table 1: Minimum maximum range for quantitative traits associated with seed yield

TRAITS	Mean	Range		SD	SE	CV (%)
		Min	Max			
Days to 50% flowering (days)	57	49	69	3.54	0.44	6.24
Days to Maturity (days)	88	81	101	3.54	0.44	3.99
Plant height (cm)	134.09	61.5	186.2	27.90	3.43	20.81
Head diameter (cm)	10.38	5.6	18.1	3.04	0.37	29.33
Hundred Seed weight (g)	3.90	1.6	6.9	1.18	0.15	30.19
Volume weight /100ml (g)	32.90	24.7	43.6	4.01	0.49	12.18
Oil content (%)	32.83	26.6	41.7	2.92	0.36	8.91
Seed Yield /plant (g)	18.58	12.3	26.5	3.64	0.45	19.60

SD – Standard Deviation, SE – Standard Error, CV (%) - Coefficient of Variation

Riaz *et al.* (2019) for head diameter and Dudhe *et al.* (2020) for hundred-seed weight. Moderate PCV and GCV were observed for volume weight (12.18 and 10.49) and seed yield per plant (19.60 and 17.16). These results are confirmatory with the findings of Neelima *et al.* (2016), Singh *et al.* (2019), and Varalakshmi *et al.* (2020). Low PCV and GCV were observed for days to 50% flowering (6.24 and 6.15), days to maturity (3.99 and 3.89), and oil content (8.91 and 8.67). High PCV and moderate GCV were observed for plant height (20.81 and 19.77). In this study, the phenotypic coefficient of variance was noticeably greater than the genotypic coefficient of variance, demonstrating the importance of environmental influences on these characteristics.

In the germplasm, substantial heritability and high genetic advance as a percentage of mean were found for plant height (90.29 and 38.71), head diameter (97.28 and 58.78), hundred seed weight (90.16 and 56.08), and seed yield per plant (76.62 and 30.94), Table 2. Results of Reddy and Nadaf (2014), Supriya *et al.* (2016), Rani *et al.* (2017), and Divya *et al.* (2019) are in line with the ones above for seed yield per plant and hundred seed weight. These findings clearly demonstrate that additive gene activity was responsible for the variance observed among the sunflower genotypes. High breeding value is directly connected with a high level of an additive gene effect. For the development of desired traits to be utilized in a breeding programme, selecting superior genotypes in an early generation is very useful. With a moderate genetic advance as a percentage of the mean, days to fifty percent flowering (97.21 and 12.50), volume weight

(74.16 and 18.61), and oil content (94.68 and 17.37) demonstrated substantial heritability, indicating both additive and non-additive gene action governing these traits. Hence, this attribute has a negligible impact on the genotypes that can be chosen. High heritability and low genetic advance (94.93% and 7.80%, respectively) were observed for days to maturity. These outcomes are analogous to the findings of Neelima *et al.* (2016), Singh *et al.* (2019), and Varalakshmi *et al.* (2020).

Path analysis: To select plants, Dewey and Lu (1959) used path coefficients to determine the type of correlation between the two variables. The contribution of various independent traits to dependent traits, both directly and indirectly, is measured by this coefficient. In this study, path coefficient analysis (Table 3) showed that days to maturity (0.588), head diameter (0.897), hundred seed weight (0.031), and oil content (0.008) had a direct positive effect on seed yield per plant. These outcomes are consistent with the findings of Pandya *et al.* (2015). There was a direct negative impact on seed yield for days to 50% flowering (-0.540), plant height (-0.088), and volume weight (-0.015). Days to 50% flowering, plant height, head diameter, hundred-seed weight, volume weight, and oil content had an indirect positive effect on seed yield through days to maturity. Reavanth *et al.*, (2022), Kamalnathu *et al.*, (2022) and Rani *et al.*, (2016) had similar moderate adverse effects *via* days to fifty percent flowering. An indirect significant effect of head diameter on seed yield per plant through days to fifty percent flowering, days to maturity, plant height, hundred seed weight, and oil content was observed. The same was reported by Pandya *et al.*, (2015), Rani *et al.*, (2016), Baraiya *et al.*, (2018) and Sasikala *et al.*, (2020),

Table 2: Variance estimates of yield and its contributing traits in Sunflower

TRAITS	σ^2_p	σ^2_g	PCV (%)	GCV (%)	h^2 (%)	GAM (%)
Days to 50% flowering (days)	12.52	12.17	6.24	6.15	97.21	12.50
Days to Maturity (days)	12.52	11.89	3.99	3.89	94.93	7.80
Plant height (cm)	778.68	703.10	20.81	19.77	90.29	38.71
Head diameter (cm)	9.27	9.01	29.33	28.93	97.28	58.78
Hundred Seed weight (g)	1.39	1.25	30.19	28.67	90.16	56.08
Volume weight /100ml (g)	16.05	11.91	12.18	10.49	74.16	18.61
Oil content (%)	8.55	8.09	8.91	8.67	94.68	17.37
Seed Yield /plant (g)	13.26	10.16	19.60	17.16	76.62	30.94

σ^2_p – Phenotypic variance, σ^2_g – genotypic variance, PCV (%) - Phenotypic coefficient of variation; GCV (%) - Genotypic Coefficient of variation; h^2 (%) – heritability; GAM (%) – Genetic Advance as percent of mean

Table 3. Path coefficient analysis indicating direct and indirect effects of characters on seed yield in Sunflower

Traits	DFF	DM	PH	HD	HSW	VW	OC	Correlation for SYPP
DFF	-0.540	0.583	-0.025	0.066	0.011	-0.001	0.001	0.095
DM	-0.535	0.588	-0.023	0.062	0.011	-0.001	0.001	0.103
PH	-0.155	0.153	-0.088	0.445	0.011	-0.002	-0.001	0.363**
HD	-0.040	0.041	-0.044	0.897	0.010	0.002	0.002	0.867**
HSW	-0.200	0.212	-0.030	0.278	0.031	-0.003	0.001	0.288*
VW	-0.037	0.034	-0.011	-0.115	0.007	-0.015	0.002	-0.135
OC	-0.084	0.096	0.008	0.171	0.004	-0.004	0.008	0.198

** - Significance at 1% level; * - Significance at 5% level.

DFF- Days to fifty percent flowering; DM- Days to maturity; PH-Plant height (cm); HD- Head Diameter (cm); HSW- Hundred seed weight (gm); VW- Volume weight per 100 ml; OC- Oil Content (%); SYPP- Seed yield per plant (gm)

Principal Component Analysis: PCA analysis is a multivariate technique used for the identification of genetic diversity; through the reduction of a large number of variables present in the data set, as well as the resulting data set, which includes almost all the information from a large set. Eight PCs, equal to the number of traits, were obtained from PCA (Table 4). Three out of eight PCs exhibited more than one eigen value and accounted for about 73.85% of the total variation. A similar wider divergence was observed by Shamshad *et al.* (2014), Deshmukh *et al.* (2016), and Naik *et al.* (2018). PC1 had the highest variability (35.21%), followed by PC2 (23.01%) and PC3 (15.63%) for the traits under study. In PC2 and PC3, hundred seed weight, volume weight, and oil content

showed positive values, indicating they contribute to the high variation in those components. The present findings align with several studies (Chandirakala and Manivannan, 2014; Naik *et al.*, 2018; Neelima *et al.*, 2016). The biplot showed that variables and genotypes are superimposed on the plot as vectors (Fig. 1 & 2). The biplot shows that the days to 50% flowering, days to maturity, hundred-seed weight, and seed yield per plant vectors overlap, indicating they are highly correlated.

CONCLUSION

To conclude, the present variability studies among sunflower genotypes showed that the characters head diameter and hundred-seed weight have high PCV and

Table 4. Principle component analysis of sunflower genotypes

	PC1	PC2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8
Eigen values	2.82	1.84	1.25	0.99	0.78	0.60	0.34	0.09
Variance percentage	35.21	23.01	15.63	12.39	7.70	4.56	1.41	0.09
Cumulative percentage	35.21	58.22	73.85	86.23	93.93	98.49	99.91	100
Traits								
Days to 50% flowering	-0.420	0.465	-0.226	0.158	0.11	0.113	-0.06	-0.709
Days to maturity	-0.417	0.463	-0.224	0.189	0.098	0.141	-0.023	0.704
Plant height	-0.383	-0.144	-0.122	-0.548	0.46	-0.516	0.198	0.022
Head diameter	-0.401	-0.504	0.014	0.091	0.073	0.118	-0.746	0.016
Hundred seed weight	-0.393	0.068	0.151	-0.295	-0.835	-0.184	0.021	0.003
Volume weight	-0.075	0.238	0.674	-0.445	0.226	0.48	-0.064	0.004
Oil content	-0.179	0.055	0.638	0.551	0.118	-0.485	0.073	-0.003
Seed yield /plant	-0.387	-0.480	0.015	0.205	-0.007	0.433	0.624	-0.03

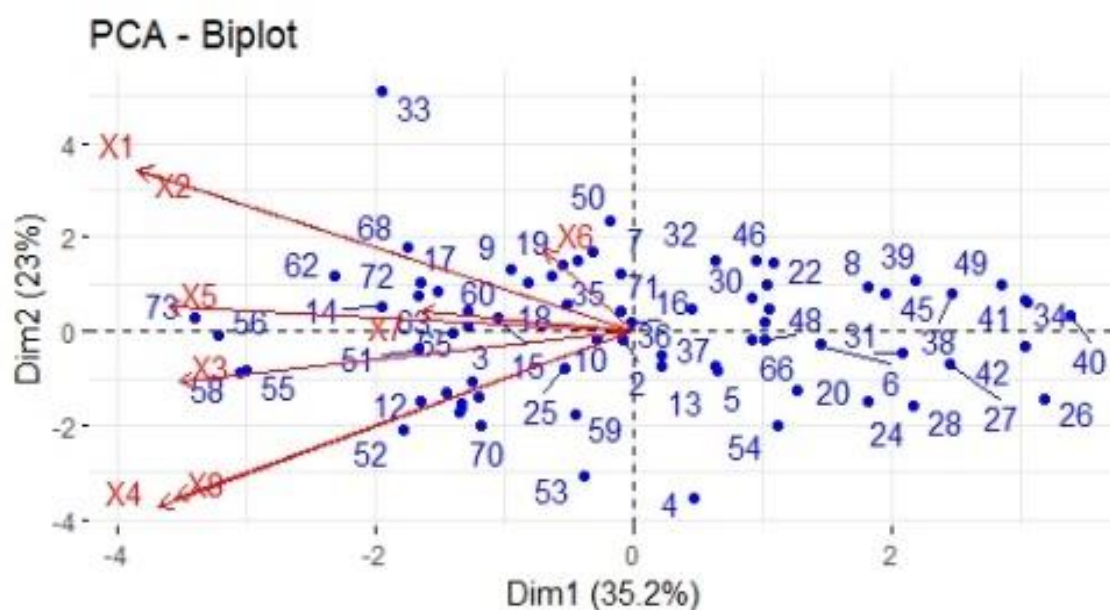


Fig 1. PCA biplot of sunflower genotypes

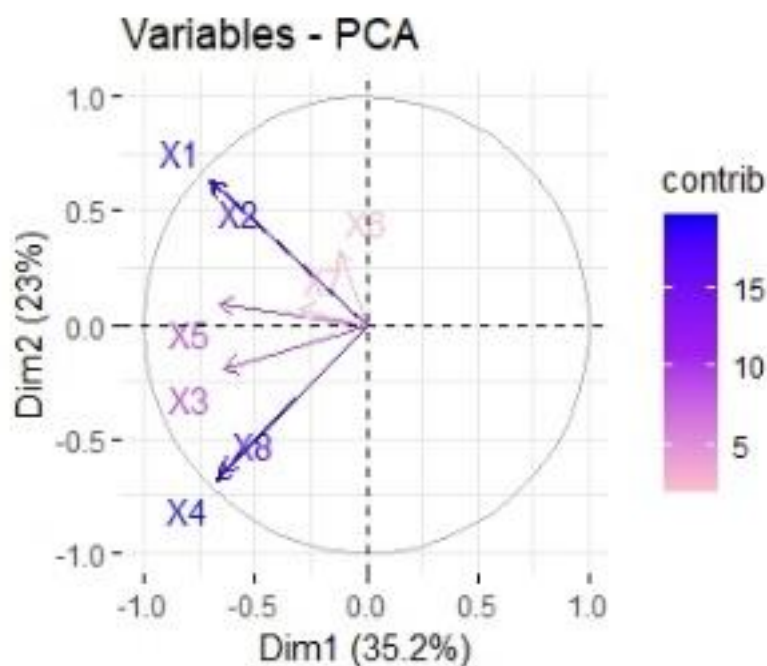


Fig. 2. PCA variables of Sunflower genotypes for the eight principal components

GCV, along with high heritability and genetic advance as a percent of the mean. Therefore, selection based on the above traits can be effective for choosing parental lines for a hybridization programme to generate superior heterotic hybrids. Based on the path coefficient analysis results, days to maturity, head diameter, hundred seed weight, and oil content had high or moderate direct effects on seed yield. Similarly, principle component analysis showed that 3 out of 8

PCs accounted for 73.85% of the total variation, and the days to 50% flowering, days to maturity, hundred seed weight, and seed yield per plant vectors are overlapping, indicating they are highly correlated. Hence, selecting superior genotypes based on these traits would be useful for improving seed yield in sunflower.

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Ethics Statement:

The author declares that the study is actual and novel in its interpretations.

Competing Interests

The authors declare that they do not have any conflict of interest

Author's Contribution

Conceptualization and designing of the research work: R.Sasikala

Execution of field /lab experiments and data collection: R.Sasikala

Analysis of data and interpretation: V.Santhiya and D.Susmitha

Preparation of manuscript and finalization: V.Santhiya, R.Sasikala, and T.Kalaimagal

Abbreviations

PCV: Phenotypic coefficient of variation

GCV: Genotypic Coefficient of variation

GCA: Genetic Advance as a percent of the mean

PCA: Principal Component Analysis

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