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Research Article

Genetic variability and association studies in BC_3F_1 population of sunflower(*Helianthus annuus* L.)

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Abstract
Variability and association studies for oil yield and its component traits were investigated in BC3F1 population of a cross between IR6 (recurrent parent with low oleic acid content) and HO5-29 (donor parent with high oleic acid content). Among 12 traits studied, volume weight (g/100 ml) , head diameter (cm), oil yield per plant (%), seed yield per plant (g), oleic acid (%), linoleic acid (%), palmitic acid (%), and stearic acid (%) displayed high phenotypic coefficient of variation and genotypic coefficient of variation along with moderate or high heritability and genetic advance as a percent of mean. This suggests that these traits are mainly under the control of additive gene action. Hence, selection based on these characters could significantly improve these traits in this population. The traits such as days to flowering, 100-seed weight (g), and stearic acid (%) have shown a platykurtic distribution which represents that these characters are amenable for selection towards further improvement. Correlation analysis showed that positive correlation between oil yield per plant and all traits, except with days to flowering. Path analysis on seed yield indicated that head diameter alone had a high positive direct effect and other traits had low direct effects. Hence, selection for head diameter can improve the seed yield in sunflower.

Keywords: Sunflower, variability, oleic acid, correlation, path analysis

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the major sources of vegetable oil after palm, soybean and mustard in the world (Statista Search Department 2023). In recent years, there has been a notable rise in sunflower production due to its modest production requirements, high oil quality, protein content, and utilization of all plant parts of the plant. In the fiscal year 2022, India produced 190 thousand metric tons of sunflower oilseeds (Statista Search Department 2023). Moreover, as reported by the USDA, the United States witnessed a substantial increase in sunflower production, with a total of 2.81 billion pounds in 2022, marking a 48% rise from the 1.9 billion pounds produced in 2021 (U.S.Sunflower Crop Quality Report 2022).When breeding high-oil sunflower varieties and hybrids, it is important to focus on high oil concentration and oil quality in the seed. The quality of the oil depends mainly on its nutritional components. Sunflower oil catogorised in two main types: the standard type i.e., high linoleic acid (a polyunsaturated fatty acid) type and the high oleic (a monounsaturated fatty acid) type. High oleic sunflower oil is known for its healthier fat profile, prolonged shelf life, stability, and oxidation resistance. Hence, it is well-suited for high-heat cooking, such as frying and deep-frying. As a result, there is a significant demand for high-oleic sunflower oil in the food industry.

The current study focuses on the improvement of oleic acid content in sunflower. It is essential to assess the variability for oil yield and component traits in the population. Determining heritability and genetic advance provides insights into gene action. Additionally understanding the relationship between various characters through correlation and path analyses helps in formulation of effective selection indices for the breeding programme. With this background, the present study was attempted in a BC_3F_1 population.

MATERIALS AND METHODS

The experimental material for the present investigation consists of a backcross population *viz.* BC_3F_1 derived from the cross IR 6 x HO 5-29. Recurrent parent IR6, an inbred with high oil (38-42%) and low oleic acid content (45-50 %). Donor parent HO 5-29 has low oil (28-32 %) with high oleic acid content (85-90%).This population was evaluated during r*abi/summer,* 2023 at the Oilseeds Farm, Centre of Plant Breeding and Genetics (CPBG), Tamil Nadu Agricultural University, Coimbatore. The population comprising 80 progenies along with parents were grown under well-irrigated condition. Observations on 12 traits *viz.* days to flowering (days to first opening of flower), plant height (cm), head diameter (cm), volume weight(g/100 ml), 100-seed weight(g), oil content (%), oil yield per plant(g), seed yield per plant(g), linoleic acid (%), oleic acid(%), palmitic acid (%) and stearic acid(%) were recorded on single plant basis on all plants. The fatty acid composition was estimated by using Near infrared spectrometre (Zeutech, Germany).

The formulae suggested by Johnson *et al*. (1955) were used to calculate the variability parameters, *viz*., phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2), and genetic advance as a percentage of mean (GAM). Sivasubramanian and Madhavamenon (1973) provided the basis for categorizing PCV and GCV into low (<10%), moderate (10-20%), and high (>20%) ranges. Simple correlation analysis adhered to the standard method devised by Karl Pearson (1896). The approach recommended by Dewey and Lu (1959) was employed for path coefficient analysis on seed yield. The statistical procedures, encompassing correlation and path analysis, were conducted using the TNAUSTAT statistical package (Manivannan, 2014).

RESULTS AND DISCUSSION

The mean and variability parameters for various traits were presented in **Table 1**. The results indicated that there was considerable variations for head diameter (cm), volume weight(g/100 ml), seed yield per plant (g), oil yield per plant (%), linoleic acid (%), palmitic acid (%), and stearic acid (%), as indicated by high values for both PCV and GCV. Oleic acid content recorded moderate PCV and GCV. Moreover, these characters exhibited high heritability, coupled with a significant genetic advance as a percentage of the mean. These results indicated that these traits were primarily influenced by additive gene effects. The results of this study are consistent with earlier research, such as Baraiya and Patel (2018) and Divya *et al.* (2019). They also reported high GCV and PCV values for all these traits. Similar results of high heritability and GAM were obtained for traits such as head diameter and seed yield per plant in a study conducted by Muthupriya *et al.* (2016) and Supriya *et al.* (2016). Oil content had low GCV, heritability, and GAM which indicated less variability and more influence of the environment. Premnath *et al*. (2014) also reported similar findings for oil content. In contrast, the trait 100-seed weight exhibited high heritability but low GAM. This indicated the influence of non-additive gene action as reported by Premnath *et al.* (2014). Hence, selection may not be effective for this trait. The GCV and PCV for traits *viz*., head diameter (cm), linoleic acid (%) are almost equal which indicated the negligible influence of environment on these traits.

Table 1. Variability parameters of BC_3F_1 population

Characters	Mean	Minimum	Maximum	PCV(%)	GCV(%)	h^2 (%)	GAM (%)	Skewness	Kurtosis
Days to Flowering	65.75	64.00	68.00	2.30	1.35	34.35	1.63	0.32	-1.37*
Plant height (cm)	125.63	80.30	150.10	9.81	7.35	56.08	11.34	-1.33**	4.59**
Head diameter (cm)	11.70	4.20	18.20	26.78	25.13	88.07	48.59	-0.22	-0.08
100-seed weight (g)	3.10	1.63	4.90	26.28	13.92	28.04	15.18	0.08	-0.56
Volume weight(g/100ml)	37.61	16.26	51.41	28.23	24.78	77.04	44.80	-0.68	-1.09
Seed yield/plant (g)	23.24	8.01	51.85	47.89	45.81	91.50	90.28	0.46	-0.33
Oil content (%)	38.22	27.16	46.76	14.30	4.73	10.94	3.22	-0.47	-0.93
Oil yield/plant (g)	9.12	2.28	23.38	53.66	50.08	87.11	96.29	0.56	0.06
Linoleic acid (%)	28.38	3.38	49.15	38.45	38.21	98.72	78.20	-0.28	-0.18
Oleic acid (%)	56.45	36.69	81.44	19.61	19.04	94.28	38.09	0.50	-0.29
Palmitic acid (%)	11.02	4.37	19.97	39.74	37.84	90.68	74.24	0.42	-1.13
Stearic acid (%)	4.52	1.35	7.70	34.70	22.91	43.60	31.17	-0.12	-0.89

*,** significant at 5 and 1 per cent level respectively

The traits plant height and days to flowering recorded low PCV and GCV as reported by Mijic *et al*. (2009).

Skewness quantifies how much a distribution deviates from symmetry, while kurtosis measures the level of peakedness in the distribution. Significant negative and positive kurtosis were seen for traits days to flowering and plant height. It indicated the platykurtic and leptokurtic nature for these traits respectively. The presence of wide and narrow variation for days to flowering and plant height respectively was indicated from these results. However, the estimates of heritability and genetic advance indicated that the wide variation in head diameter is due to the environment. The significant negative skewness for plant height indicated that the population has more proportion of taller plants. The heritability and GAM also indicated the presence of additive gene action for this trait. Hence, the improvement can be made towards taller plants only.

Correlation coefficients among oil yield and component traits were presented in **Table 2.** There is a significant positive correlation of oil yield per plant with all other traits, except with days to flowering. Similar findings were obtained by Sowmya *et al*. (2010), Dan *et al*. (2012), Srinivasa Reddy *et al.* (2014), Ramzan *et al*. (2015) and Nandini *et al*. (2017).The trait days to flowering had a significant and negative correlation with 100-seed weight. Similar results were obtained by Adare (2014). Plant height had showed significant and positive correlation with all traits except with oil content. Head diameter, 100-seed weight, volume weight, oil content, and seed yield had significant and positive association among themselves. Hence, traits *viz*., plant height, head diameter, 100-seed weight, volume weight, oil content, and seed yield are the selection indices for the improvement of oil yield per plant as per the correlation analysis.

Path analysis on seed yield was presented in **Table 3**. The residual value of 0.38 indicated that most of the traits related to seed yield were included in the path analysis. The results of path analysis indicated that head diameter had a high direct effect on seed yield per plant **(**0.439**)**. Lagiso *et al.* (2021) and Radic *et al.* (2021) also reported similar findings. The coefficient values for days to flowering (0.172), plant height (0.142), 100-seed weight (0.136), and oil content (0.149) shows that these traits had a low direct effect on seed yield plant. These findings were similar to Ramzan *et al*. (2015) for days to flowering and plant height and to Maria *et al*. (2018) for 100 seed weight and oil content. In a study conducted by Kamalnathu *et al*. (2022), it was noted that oil content had a moderate direct impact on seed yield per plant in high oleic populations. In the case of indirect effects, 100-seed weight had a positive moderate indirect effect via head

Table 2. Simple correlation with oil yield and component characters in the BC_3F_1 population

Characters	Days to Flowering	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Volume weight (g/100 ml)	Seed yield/ plant (g)	Oil content (%)
Plant height (cm)	-0.025						
Head diameter (cm)	-0.027	0.425**					
100-seed weight (g)	-0.322*	0.315*	0.570**				
Volume weight(g/100ml)	0.089	0.363**	0.423**	0.339*			
Seed yield/plant (g)	-0.264	0.381**	0.657**	0.554**	0.356**		
Oil content (%)	-0.210	-0.072	0.400**	0.325*	0.317*	0.409**	
Oil yield/plant (g)	-0.254	0.359**	0.677**	0.583**	0.420**	0.970**	0.591**

*,** significant at 5 and 1 per cent level respectively

Table 3. Path analysis on seed yield per plant in the BC_3F_1 population

Characters	Days to Flowering	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Volume weight (g/100 ml)	Oil content (%)	Correlation coefficient with seed yield/plant (g)
Days to Flowering	**-0.172**	-0.004	-0.013	-0.044	0.004	-0.031	-0.265
Plant height (cm)	0.005	**0.142**	0.184	0.042	0.017	-0.010	0.381**
Head diameter (cm)	0.005	0.060	**0.439**	0.078	0.019	0.059	0.657**
100-seed weight (g)	0.055	0.044	0.250	**0.136**	0.016	0.049	0.555**
Volume weight (g/100ml)	-0.015	0.051	0.184	0.046	**0.046**	0.048	0.356**
Oil content (%)	0.036	-0.010	0.175	0.045	0.015	**0.149**	0.409**

Residual effect=0.38; ** significant at 1 per cent level diameter on seed yield per plant. These results were similar to Pandya and Narwade (2015). Traits *viz*., plant height, volume weight, and oil content had a low indirect effect *via* head diameter on seed yield per plant. All the remaining traits had minimal or negligible indirect effects on seed yield per plant. Hence, based on path analysis, head diameter is the important selection index for seed yield per plant.

In view of the above discussion, it can be concluded that traits such as head diameter (cm), volume weight (g/100 ml), seed yield per plant (g), oil yield per plant (%), oleic acid (%), linoleic acid (%), palmitic acid (%), and stearic acid (%) showed high or moderate PCV, GCV, heritability and GAM. Hence, these traits can be relied upon for effective selection due to the presence of additive gene action. Correlation analysis revealed a significant correlation between seed yield per plant and all studied traits, except for days to flowering. Path analysis on seed yield showed that head diameter had a high direct effect on seed yield per plant. Additionally Plant height (cm), 100-seed weight, volume weight, and oil content also had a low to moderate indirect effects via head diameter on seed yield per plant. Hence, the trait head diameter can be considered as an important selection index for the improvement of seed yield per plant.

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