Received: 24 May 2022 | Revised: 15 Jun 2022 | Accepted: 28 Jun 2022

Electronic Journal of Plant Breeding

Research Article

Selection indices for oil content and oil yield improvement in low and high oleic acid content populations in sunflower (*Helianthus annuus* L.)

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Abstract
A F_2 population was partitioned into low oleic and high oleic acid content groups using a high oleic allele-specific marker. These low and high oleic acid content groups and pooled groups were subjected to variability and association analyses. The variability parameters were similar in both high oleic and low oleic populations. Traits *viz*., plant height, head diameter, 100-seed weight, seed yield and oil content are considered as selection indices for improving oil yield. These selection indices can be followed to improve oil yield in both high oleic and low oleic populations. However, separate selection indices to improve oil content *viz*., volume weight, plant height and head diameter for high oleic acid populations and volume weight, days to flowering and 100-seed weight for a low oleic populations may be followed. These results indicated that similar selection indices could not be adopted to improve a trait in all populations.

Keywords: Sunflower, high oleic acid content, oil yield, variability, correlation.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) (2n=34) is the third most important oilseed crop after soybean and groundnut. Sunflower seed oil is one of the sources of healthy edible oil and contains a high percentage of unsaturated fatty acid (90%) with linoleic acid and oleic acid. Oil with high oleic acid content has more demand worldwide due to its excellent oxidation resistance and is suitable for an extended frying period (Premnath *et al.,* 2014). Sunflower is grown in an area of 2.3 lakh hectares with a production of 1.4 lakh tonnes and productivity of 0.61 tonnes per hectare in India (Anonymous, 2020). It is primarily grown in Karnataka, Maharashtra and Andhra Pradesh and to some extent in states like Haryana, Punjab, Uttar Pradesh, Gujarat, Tamil Nadu, Orissa, Madhya Pradesh and Rajasthan.

Genetic improvement of sunflower depends mainly on variability for yield and yield component traits. The study of heritability helps to partition the heritable and non-heritable components, which is helpful for the effective selection of heritable traits. Heritability, along with genetic advance helps to identify the gene action (Divya *et al.,* 2019). Understanding the association between the yield and yield component traits is helpful for the formulation of selection indices for an effective breeding programme in any crop. However, fixed selection indices may not be effective for the various trait improvement programme. Thus, considering all these points, the present study was formulated for identifying the selection indices for oil yield improvement programmes in low and high oleic acid content populations in sunflower.

MATERIALS AND METHODS

The experiment was conducted with 269 F_2 plants derived from a cross IR6 x HO 5-29. Parent IR6 is a restorer line with high oil content (39-42 %) and low oleic acid content (40-45%). The parent HO 5-29 is also a restorer line with low oil content (30-33 %) and high oleic acid content (80-85%). The F_2 population along with parents were evaluated at the Oilseeds Farm, Centre of Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore during *rabi,* 2021-22. Recommended crop management practices were followed as per the Crop Production Guide of Tamil Nadu under irrigated conditions. Observations were recorded on a single plant basis on the F_2 population and along with parents for eight traits *viz.,* days to first flowering, plant height (cm), head diameter (cm), volume weight (g/100ml), 100-seed weight (g), seed yield per plant (g), oil content (%) and oil yield per plant (g). Thus, 269 F_2 plants were taken as pooled population. Based on the high oleic allele-specific marker (Lacombe *et al.,* 2009), the F_2 population was divided into two groups *viz*., low and high oleic acid content types. The presence of an 891bp band indicates high oleic acid content between 65 and 90% in seeds. Thus, 91 and 80 F_2 plants were taken as low oleic population and high oleic population, respectively. Various statistical methods were adopted to analyse the grouped populations *viz*., low oleic, high oleic and pooled populations. The statistical parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2), and genetic advance as per cent of mean (GAM) were calculated. The PCV and GCV were classified as low, moderate and high as suggested by Sivasubramanian and Madhavamenon (1973). The range of heritability (%) and genetic advance as per cent of mean (GAM) was also classified as low, moderate and high by following Johnson *et al.* (1955). Simple correlation analysis was carried out as per the standard method (Karl Pearson, 1896). Path coefficient analysis was carried out as per the standard method suggested by Dewey and Lu (1959). The statistical analysis *viz*., correlation and path analysis was carried out using TNAUSTAT statistical package (Manivannan, 2014).

Table 1. Variability parameters in F_2 population of cross IR6 x HO 5-29

Trait	Population	Mean	Minimum	Maximum	PCV (%)	GCV (%)	h^2 (%)	GAM (%)
	Pooled	62.43	50.00	86.00	6.97	6.56	88.47	12.71
Days to first flowering	HO	61.98	50.00	86.00	7.77	7.40	90.59	14.50
	LO	62.01	50.00	73.00	6.63	6.19	87.09	11.90
	Pooled	129.78	89.20	167.20	10.99	8.92	65.89	14.91
Plant height (cm)	HO	130.89	89.20	160.30	11.42	9.48	68.96	16.22
	LO	127.18	94.50	164.80	11.27	9.17	66.22	15.37
	Pooled	15.04	5.60	23.50	23.26	22.28	91.78	43.97
Head diameter (cm)	HO	14.27	5.60	23.50	24.64	23.61	91.86	46.62
	LO	14.71	7.80	22.30	23.78	22.78	91.78	44.96
	Pooled	35.99	24.85	48.46	11.83	5.48	21.50	5.24
Volume weight (g/100 ml)	HO	36.68	26.34	48.46	11.55	5.27	20.80	4.95
	LO	36.93	27.66	46.70	11.66	5.63	23.29	5.60
	Pooled	3.14	0.48	7.31	33.84	32.69	93.33	65.06
100-seed weight (g)	HO	2.94	1.34	6.54	33.59	32.27	92.29	63.86
	LO	3.02	0.48	5.51	32.18	30.87	92.02	61.01
	Pooled	33.33	3.70	95.90	57.24	56.22	96.47	113.75
Seed yield per plant (g)	HO	29.95	4.10	82.80	55.06	53.74	95.28	108.07
	LO	31.98	3.70	91.00	55.02	53.86	95.85	108.63
	Pooled	34.09	22.02	43.33	13.79	11.51	69.71	19.80
Oil content (%)	HO	33.29	22.02	43.33	14.19	11.88	70.04	20.48
	LO	34.25	23.91	41.76	12.96	10.53	66.03	17.63
	Pooled	11.62	1.21	37.73	63.04	62.00	96.73	125.61
Oil yield per plant (g)	HO	10.13	1.59	29.73	59.22	57.75	95.12	116.03
	LO	11.01	1.49	33.27	57.54	56.26	95.62	113.33

HO- High oleic acid content population
LO-Low oleic acid content population

RESULTS AND DISCUSSION

The genetic variability present in the experimental population decides the success of any breeding programme. Variability parameters of high oleic, low oleic and pooled populations are presented in **Table 1**. The phenotypic coefficient of variation (PCV) was slightly higher than the genotypic coefficient of variation (GCV) for all traits. The trait *viz*., volume weight had the highest difference between PCV and GCV in all groups, which indicated that volume weight was highly influenced by environmental effects. Similar results were reported by Divya *et al.* (2019). Among traits, head diameter, 100-seed weight, seed yield and oil yield per plant had high GCV in all populations. It indicated the presence of a high amount of genetic variability for these traits and similar results were reported by Supriya *et al.* (2016) and Divya *et al.* (2019). Other traits *viz*., days to first flowering, plant height, volume weight and oil content recorded low GCV in all populations. Similar results were obtained by Premnath *et al.* (2014) and Chandirakala *et al.* (2017). Traits *viz.,* head diameter, 100-seed weight, seed yield per plant and oil yield per plant showed high heritability with high genetic advance as per cent of mean in all populations. It indicated the presence of additive gene action and selection might be effective for these traits in all populations. Similar results were reported by Chandirakala *et al.* (2017), Nandini *et al.* (2017) and Divya *et al.* (2019). The traits *viz.,* days to first flowering and plant height exhibited high heritability with moderate genetic advance as per cent of mean. It indicated the presence of additive gene action in these traits also and hence selection might be effective for these traits improvement in all populations. The traits *viz.,* volume weight showed low heritability and low genetic advance as per cent of mean in all populations. It indicated the trait volume weight is highly influenced by environmental effects and selection might not be effective. The variability parameters are all at a similar level in all three populations irrespective of their oleic content types.

The correlation coefficient analysis revealed the nature and degree of association between the component traits and oil yield. The correlation coefficients among various traits in all populations are presented in **Table 2**. Oil yield per plant showed a positive and significant correlation with plant height, head diameter, 100-seed weight, seed yield per plant and oil content in all populations. Similar results were reported by Premnath *et al.* (2014) and

Table 2. Simple correlation coefficient in F_2 population of cross IR6 X HO 5-29

Trait	Population	Days to first flowering	Plant height	Head diameter	Volume weight	100-seed weight	Seed yield per plant	Oil content
	Pooled	0.20**						
Plant height	HO	0.18						
	LO	0.18						
	Pooled	0.17**	0.38**					
Head diameter	HO	0.16	0.39**					
	LO	0.15	0.41**					
	Pooled	-0.12	-0.02	-0.20**				
Volume weight	HO	-0.06	-0.01	-0.25*				
	LO	-0.01	-0.09	-0.18				
	Pooled	-0.03	0.25**	0.64**	0.07			
100-seed weight	HO	0.08	0.22	0.80**	-0.10			
	LO	-0.10	0.18	0.60**	0.07			
	Pooled	-0.08	0.35**	0.76**	-0.05	0.77**		
Seed yield per plant	HO	0.03	0.36**	0.78**	-0.14	0.87**		
	LO	-0.14	0.34**	0.77**	-0.15	0.76**		
	Pooled	0.29**	0.20**	0.29**	0.43**	0.34**	0.29**	
Oil content	HO	0.23	0.28*	0.27**	0.52**	0.22	0.21	
	LO	0.42**	0.10	0.19	0.44**	0.22*	0.07	
	Pooled	-0.02	0.36**	0.74**	0.03	0.78**	0.98**	0.44**
Oil yield per plant	HO	0.08	0.39**	0.77**	-0.03	0.86**	0.97**	0.39**
	LO	-0.06	0.32**	0.77**	-0.05	0.78**	0.98**	0.24*

*, ** Significant at 5% and 1% level, respectively
HO- High oleic acid content population; LO-Low oleic acid content population

Nandini *et al.* (2017). Oil content showed a positive and significant correlation with volume weight in all populations. Oil content showed a positive and significant correlation with plant height and head diameter in pooled and high oleic populations. Days to first flowering and 100-seed weight showed a positive and significant correlation with oil content in pooled and low oleic populations. Seed yield per plant had a significant and positive correlation with oil content in pooled population only. These results indicated that traits *viz.,* plant height, head diameter and volume weight were the important selection indices to improve oil content in high oleic populations. Likewise, traits *viz*., days to first flowering, volume weight and 100-seed weight should be considered to improve the oil content in low oleic populations. The trait plant height, head diameter and 100-seed weight showed a positive and significant correlation with seed yield per plant in all three populations. The traits *viz*., head diameter and 100-seed weight showed a positive and significant correlation with plant height and head diameter, respectively in all three populations. Volume weight showed a positive and significant correlation with head diameter in pooled and high oleic populations. Head diameter and plant height had a significant association with days to flowering in pooled populations only. Similar results were reported by Dan *et al.* (2012). Hence, traits *viz*., plant height, head diameter, 100-seed weight, seed yield and oil content were important selection indices for improving oil yield in both low and high oleic populations. However, traits *viz*., volume weight, days to flowering and 100-seed weight should be considered as selection indices to improve the oil content in low oleic populations. In the case of high oleic populations, traits *viz*., volume weight, plant height and head diameter should be considered as selection indices to improve oil content. The differential association with oil content might be due to the fact that the oleic acid and oil content had a negative association (Radic *et al.,* 2008; Haddadi *et al.,* 2010; Onemli, 2012; Abd EL-Satar *et al.,* 2017;

Table 3. Path coefficient analysis in F_2 population of cross IR6 X HO 5-29 for various traits on oil yield per plant

Trait	Population	Days to first flowering	Plant height	Head diameter	Volume weight	100-seed weight	Seed yield per plant	Oil content	Correlation coefficient with oil yield per plant
Days to first flowering	Pooled	**0.018**	-0.002	-0.006	-0.001	0.000	-0.078	0.049	-0.020
	HO	**0.010**	0.000	-0.003	0.000	0.001	0.028	0.047	0.083
	LO	**0.018**	-0.006	0.000	0.000	-0.001	-0.136	0.064	-0.061
Plant height	Pooled	0.004	**-0.009**	-0.012	0.000	0.000	0.339	0.034	0.355**
	HO	0.002	**0.001**	-0.008	0.000	0.002	0.340	0.057	0.392**
	LO	0.003	**-0.035**	0.001	-0.003	0.002	0.333	0.016	0.317**
Head diameter	Pooled	0.003	-0.004	**-0.033**	-0.001	0.001	0.728	0.048	0.743**
	HO	0.002	0.000	**-0.021**	0.001	0.006	0.730	0.056	0.773**
	LO	0.003	-0.014	**0.003**	-0.006	0.007	0.750	0.029	0.771**
Volume weight	Pooled	-0.002	0.000	0.007	**0.005**	0.000	-0.049	0.072	0.033
	HO	-0.001	0.000	0.005	**-0.005**	-0.001	-0.130	0.105	-0.026
	LO	0.000	0.003	-0.001	**0.033**	0.001	-0.150	0.067	-0.047
100-seed weight	Pooled	-0.001	-0.002	-0.021	0.000	**0.001**	0.744	0.057	0.779**
	HO	0.001	0.000	-0.017	0.000	**0.007**	0.821	0.045	0.858**
	LO	-0.002	-0.006	0.002	0.002	**0.011**	0.743	0.033	0.784**
Seed yield per plant	Pooled	-0.001	-0.003	-0.025	0.000	0.001	**0.961**	0.049	0.980**
	HO	0.000	0.000	-0.016	0.001	0.006	**0.941**	0.042	0.974**
	LO	-0.003	-0.012	0.002	-0.005	0.008	**0.977**	0.011	0.979**
Oil content	Pooled	0.005	-0.002	-0.009	0.002	0.000	0.278	**0.168**	0.442**
	HO	0.002	0.000	-0.006	-0.003	0.002	0.195	**0.204**	0.394**
	LO	0.007	-0.004	0.001	0.014	0.002	0.071	**0.153**	0.245*

*, ** Significant at 5% and 1% level, respectively

Residual effect: Pooled = 0.103; HO population = 0.108; LO population = 0.094

HO- High oleic acid content population; LO-Low oleic acid content population

Ahmadian *et al.,* 2019). However, no association (Premnath *et al.,*2014; Ferfuia *et al.,* 2015; Gjorgjieva *et al.,* 2015) and positive association (Velasco *et al.,* 2007) between oil content and oleic acid content were reported by many authors.

The residual effect was negligible indicates that selected traits were highly appropriate for path analysis on oil yield per plant. The path analysis among all traits in all three population were presented in **Table 3**. Single plant yield showed a high direct effect on oil yield per plant in all three populations irrespective of oleic acid content. Similar results were reported by Behradfar *et al.* (2009) and Mijic *et al.* (2009). Oil content recorded moderate direct effect in high oleic populations (Mijic *et al.,*2009) and low direct effect in pooled and low oleic populations on oil yield per plant. The other traits showed a negligible direct effect on oil yield per plant in all three populations. The traits head diameter and 100-seed weight had a high indirect effect on oil yield per plant via single plant yield in all three populations. Similar results were obtained by Behradfar *et al.* (2009). The trait plant height showed a moderate indirect effect on oil yield per plant via single plant yield in all three populations. Oil content had a moderate indirect effect on oil yield per plant via single plant yield in pooled population alone. However, it had a low indirect effect in high oleic population and negligible indirect effect on oil yield per plant via single plant yield in low oleic population.

In this study. variability parameters were similar in both high oleic and low oleic populations. Traits *viz*., plant height, head diameter, 100-seed weight, seed yield and oil content were considered as selection indices for improving oil yield. These selection indices could be followed to improve oil yield in both high oleic and low oleic populations. However, separate selection indices to improve oil content *viz*., volume weight, plant height and head diameter for high oleic acid populations and volume weight, days to flowering and 100-seed weight for low oleic population might be followed. These results indicated that similar selection indices could not be adopted to improve a trait in all populations.

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