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Genetic Variability and Association Analysis for Yield and Its Component Traits in Sunflower (*Helianthus annuus* L.)

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Abstract

Twenty-nine sunflower genotypes were evaluated for genetic variability and association of various morphological traits with seed yield. The genotypes were evaluated in Randomized Complete Block Design with three replications. Eight biometrical traits *viz*., days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), volume weight (g/100 mL), 100-seed weight (g), oil content (%) and seed yield per plant (g) were recorded. The phenotypic and genotypic variation washigh for seed yield per plant and 100-seed weight, indicating that selection will be effective for improving these characters. Traits with high heritability and high genetic advance were highly amenable to selection which was observed for days to 50% flowering and plant height. The trait days to maturity weregoverned by non additive gene action as it showed low genetic advance. Correlation coefficients measure the degree of relationship between two or more variables. The key trait seed yield per plant had positive significant correlation with plant height (0.61), head diameter (0.83) and 100-seed weight (0.73). Path analysis revealed that 100-seed weight (0.62), days to maturity (0.34) and head diameter (0.30) had high positive direct effect on seed yield. Head diameter had the highest positive indirect effect on seed yield per plant through 100-seed weight (0.45).

Keywords:*Sunflower; Genetic variability; Heritability; Genetic advance;Correlation;Path coefficient*

Introduction

Sunflower (*Helianthus annuus* L.) is a very important oilseed crop and stands infourth position in oilseed crops ranking in the world (Zia *et al*., 2013). It is a highly cross-pollinated crop and envisages enormous variability in succeeding generation (Hassan *et al.,* 2013). Exploiting the variability in a population is the primary criterionfor any crop improvement programme. Yield is a most complex and polygenic trait. Variability studies is an essential tool in a breeding programme as it helps identify heritable variations in a particular trait. It is also essential to measure the interrelationship between various plant attributes and determine the component characters, on which the selection procedure can be based for the genetic improvement of crop yield (Hassan *et al*., 2013). Correlation coefficient analysis measures the mutual relationship among various plant traits and determines the component traits on which selection can be based for improvement in yield. Similarly, path coefficient analysis is a powerful statistical technique that provides means to quantify the interrelationship of different yield components and indicates whether the influence is directly or indirectly on seed yield (Tyagi *et al.,* 2013). With this background, the present investigation was carried out to assess the variability and association analysis for seed yield and contributing characters in 29 inbreds of sunflower.

Material and methods

An experiment was carried out during January-April 2021 at the Department of Oilseeds research farm, Tamil Nadu Agricultural University, Coimbatore. Twenty-nine sunflower inbreds (24 maintainer and five restorer lines) were raised in Randomized Complete Block Design (RCBD) with three replications. Each entry was evaluated in a single 4m row with a spacing of 60 cm between rows and 30 cm between plants. Standard agronomic practices and plant protection measures (Crop Production Guide, 2020) were followed throughout the crop growth period. Eight biometrical traits *viz*., days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), volume weight (g/100 mL), 100-seed weight (g), oil content (%) and seed yield per plant (g) were recorded on five randomly selected plants of each genotype in all the three replications. Analysis of variance (ANOVA),phenotypic and genotypic coefficient of variability (Burton and Devane, 1953), heritability in broad sense (Lush *et al.,* 1940), genetic advance (Johnson *et al.,* 1955), correlation coefficients (Karl Pearson, 1896) and path analysis (Dewey and Lu, 1959) was worked out using GENRES software program.

Result and discussion

The results of ANOVA revealed that all characters under study showed significant difference among the genotypes indicating the presence of substantial genetic variation.

Variability studies

The results of variability analysis were presented in Table 1. The studies on different variability parameters *viz.,* phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2) and genetic advance as per cent of mean (GAM) for eight biometrical traits revealed the presence of considerable amount of heritable variations in the test genotypes which were discussed below.High PCV and GCV was observed for seed yield per plant (61.76% and 42.57%) and 100-seed weight (28.13% and 21.67%),indicating a better scope for improving these characters through simple selection. The above results are in parallel with the findings of Reddy and Nadaf (2014), Supriya*et al.* (2016), Rani *et al.* (2017) and Divya*et al.* (2019) for seed yield per plant and 100-seed weight. The traits of plant height (21.82% and 17.90%) and head diameter (20.24% and 14.98%) showed high PCV and moderate GCV as reported by Riaz *et al*. (2019). Moderate PCV and GCV values were observed for days to 50% flowering (10.41% and 10.01%) and volume weight (16.14% and 10.80%). Similar findings were reported for volume weight by Supriya*et al.* (2016) and Latha*et al.* (2017). The lower magnitude of PCV and GCV was observed for days to maturity (4.95% and 4.73%) and oil content (8.09% and 7.18%) which are in line with the findings of Reddy and Nadaf (2014), Rani *et al.* (2017), Latha*et al.* (2017), Divya*et al.* (2019), Dudhe*et al.* (2019) and Varalakshmi *et al.* (2020). The expression of low coefficients of variation for these traits indicates that there was low variation in the material evaluated, which requires searchingfor variation in other material (Supriya*et al*., 2016).Hence, the traits *viz.*, seed yield per plant, 100-seed weight, days to 50% flowering, plant height, head diameter and volume weight showed high or moderate GCV values. Therefore, selection could be effective for the improvement of these traits.

High heritability estimates were observed for days to 50% flowering (94.07%), days to maturity (91.35%), oil content (78.80%) and plant height (67.28%). Moderate heritability was observed for 100-seed weight (59.33%), head diameter (54.80%), seed yield per plant (47.52%) and volume weight (44.76%). Genetic advance as per cent of mean was high for traits *viz.,* seed yield per plant (60.45%), 100-seed weight (34.38%), plant height (30.25%), head diameter (22.85%) and days to 50% flowering (20.17%) while it was moderate for volume weight (14.88%) and oil content (13.12%) and lower for days to maturity (9.32%). High heritability coupled with high genetic advance was recorded for days to 50% flowering and plant height which indicates that the selection for these characters can be effective. These results are confirmatory with the findings of Neelima*et al.* (2016), Singh *et al.* (2019) andVaralakshmi *et al.* (2020). High heritability coupled with moderate genetic advance was recorded for oil content suggesting that this character can also be improved. Supriya*et al.* (2016), Latha*et al.* (2017), Divya*et al.* (2019) and Varalakshmi *et al.* (2020) also reported similar findings. Moderate heritability with high genetic advance was noticed for head diameter, 100-seed weight and seed yield per plant. Rani *et al.* (2017) and Riaz *et al.* (2019) for head diameter and Dudhe*et al*. (2019) for 100-seed weight and seed yield per plant reported similar findings. Hence, selection for these characters can also be effective.From the

above furnished results, it is obvious that the traits seed yield per plant and 100-seed weight had high PCV, GCV values with moderate heritability and high GAM. Hence, these traits could be improved through selection.

Correlation

Correlation for seed yield and component traits were presented in Table 2. Correlation analysis revealed that seed yield per plant had positive correlation with plant height, head diameter and 100-seed weight. Similar association was reported by Sowmya *et al.* (2010), Reddy *et al.* (2014), Ramzan *et al.* (2015) and Nandhini *et al.* (2017). With regard to inter correlation among traits other than yield, days to 50% flowering had positive significant correlation with days to maturity. Association of plant height with head diameter, volume weight and oil content were found to be significant and positive. Similar positive association with those three characters was reported early by Anandhan*et al.* (2010), Patil (2011) and Reddy *et al.* (2014). Nandhini *et al.* (2017) also found similar association for head diameter and volume weight, Sowmya *et al.* (2010) for head diameter and oil content. Negative association of plant height with head diameter was given by Baraiya *et al.* (2018) and Abro*et al.* (2020), with oil content by Dudhe*et al.* (2019). Head diameter had positive correlation with 100-seed weight. These results were parallel with the findings of Sowmya *et al.* (2010), Anandhan*et al.* (2010), Reddy *et al.* (2014), Ramzan *et al.* (2015), Nandhini *et al.* (2017), Singh *et al.* (2018), Baraiya *et al.* (2018) and Dudhe*et al.* (2019) and contrast with the report of Abro*et al.* (2020). Volume weight had significant and positive association with oil content. Likewise, Anandhan*et al.* (2010), Reddy *et al.* (2014), Nandhini *et al.* (2017) and Singh *et al.* (2018) also stated the positive significant association of volume weight with oil content.

Hence, from the above discussion it can be concluded that the traits plant height, head diameter, volume weight and 100-seed weight would be considered as selection indices for the improvement of seed yield in sunflower breeding programme.

Path analysis:

Results of path analysis on seed yield was presented in Table 3. The residual effect of path analysis on seed yield (0.06) indicates that the choice of traits is most appropriate for the path analysis on seed yield. Path coefficient analysis enables the partitioning of direct and indirect effects of individual yield components and the identification of yield components applicable as selection criteria in sunflower breeding (Radic*et al*., 2021). The results of path analysis indicated that the trait 100-seed weight (0.62) had a high positive direct effect on seed yield followed by days to maturity (0.34) and head diameter (0.30). These results are in consonance with the findings of Pandya *et al.* (2015). Moderate direct effects on seed yield were observed for plant height (0.29) and oil content (0.28). The moderate and low negative direct effect was observed for days to 50% flowering (-0.21) and volume weight (-0.12), respectively.

Head diameter had a high positive indirect effect on seed yield per plant through 100-seed weight (0.45), followed by days to 50% flowering through days to maturity (0.32). Sowmya *et al.* (2010), Ramzan *et al.* (2015) and Rani *et al.* (2017) also reported similar results of indirect effects on seed yield. Test weight showed moderate positive indirect effect *via* head diameter (0.22)Sowmya *et al.* (2010), Ramzan *et al.* (2015), Pandya *et al.* (2015), Rani *et al.* (2016) and Baraiya *et al.* (2018) also reported similarly. Days to maturity had moderate negative indirect effect *via* days to 50% flowering. Razzaq *et al.* (2014) and Rani *et al.* (2016) also reported similar moderate negative effect *via* days to 50% flowering. Low positive indirect effect on seed yield was showed by plant height *via* head diameter (0.12), 100-seed weight (0.14) and oil content (0.10), by volume weight through plant height (0.15) and oil content (0.11) and by oil content *via* plant height (0.10).Days to 50% floweringthrough 100-seed weight (-0.14), days to maturity *via* 100-seed weight (-0.17) and oil content through 100-seed weight (-0.12) showed low negative indirect effect on seed yield. Similar results were reported by Razzaq *et al.* (2014), Pandya *et al.* (2015), Rani *et al.* (2016), Lakshman *et al.* (2018), Baraiya *et al.* (2018)and Arshad *et al.* (2019). Other traits recorded negligible indirect effect on seed yield. From the results of path analysis on seed yield, it is evident that 100-seed weight, days to maturity and head diameter recorded a high direct effect on seed yield. Hence, it can be concluded that traits days to maturity, head diameter and 100-seed weight can be considered as important selection indices for improvement of seed yield in sunflower breeding programme.

Conclusion:

Based on the previous discussion, it can be concluded that traits viz., days to 50% flowering, plant height, oil content, head diameter, 100-seed weight and seed yield per plant recorded high or moderate heritability and genetic advance as per cent of mean. Hence these traits are amenable toselection.The correlation analysis revealed that plant height, head diameter, and 100-seed weight had a significant and positive association with seed yield per plant. Inter correlation among these components are also significant and positive. Path analysis on seed yield indicated that plant height, 100-seed weight, days to maturity and head diameter recorded high or moderate direct effects on seed yield. Hence, considering correlation and path analysis results, it can be concluded that traits plant height, days to maturity, head diameter and 100-seed weight can be considered important selection indices for seed yield improvement programme in sunflower.

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Ethics approval:

The author declares that the study performed is true with novelty in the interpretations.

Conflicts of interest/Competing interests:

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Table 1. Variance estimation of eight biometrical traits

Traits	PCV(%)	GCV(%)	h^2(%)	GAM(%)
Days to 50% flowering	10.41	10.09	94.07	20.17

Days to maturity	4.95	4.73	91.35	9.32
Plant height (cm)	21.82	17.90	67.28	30.25
Head diameter (cm)	20.24	14.98	54.80	22.85
Volume weight (g/100 mL)	16.14	10.80	44.76	14.88
100-seed weight (g)	28.13	21.67	59.33	34.38
Oil content (%)	8.09	7.18	78.80	13.12
Seed yield per plant (g)	61.76	42.57	47.52	60.45

PCV- Phenotypic coefficient of variation; GCV- Genotypic coefficient of variation; h^2 – heritability; GAM – Genetic advance as percent of mean

Table 2. Genotypic correlation for seed yield and component characters in sunflower

Characters	DFF	DM	PH	HD	VW	HSW	OC	SYPP
DFF	1.00	0.94**	0.00	0.12	0.13	-0.19	0.04	0.01
DM		1.00	0.05	0.11	0.18	-0.24	0.17	0.03
PH			1.00	0.40*	0.48**	0.25	0.31*	0.61**
HD				1.00	0.04	0.70**	0.09	0.83**
VW					1.00	0.17	0.33*	0.30
HSW						1.00	-0.14	0.73**
OC							1.00	0.23
SYPP								1.00

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

DFF- days to 50% flowering; DM- days to maturity; PH- plant height (cm); HD- head diameter (cm); VW- volume weight (g/100 mL); HSW- 100-seed weight (g) ; OC- oil content (%); SYPP- seed yield per plant (g)

Table 3. Path coefficient analysis on seed yield in sunflower

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Characters	DFF	DM	PH	HD	VW	HSW	OC	Genotypic correlation coefficient with SYPP
DFF	-0.21	0.32	0.00	0.03	-0.02	-0.14	0.01	0.01
DM	-0.20	0.34	0.02	0.03	-0.03	-0.17	0.05	0.03
PH	0.00	0.02	0.29	0.12	-0.06	0.14	0.10	0.61**
HD	-0.02	0.04	0.11	0.30	0.00	0.45	0.03	0.83**
VW	-0.03	0.07	0.15	0.01	-0.12	0.09	0.11	0.30
HSW	0.05	-0.09	0.06	0.22	-0.02	0.62	-0.05	0.73**
OC	-0.01	0.06	0.10	0.03	-0.05	-0.12	0.28	0.23

Residual effect = 0.064

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

DFF- days to 50% flowering; DM- days to maturity; PH- plant height (cm); HD- head diameter (cm); VW- volume weight (g/100 mL); HSW- 100-seed weight (g) ; OC- oil content (%); SYPP- seed yield per plant (g)