

Original Research Article

Assessment of Genetic Variability and Character Associations in Sunflower (*Helianthus annuus* L.) Yield Related traits

ABSTRACT

Aims: To investigate yield and yield related characteristics for variability and association studies in fifty-two powdery mildew differentials of sunflower.

Study design: Augmented block design

Place and Duration of Study: Main agricultural Research station, University of Agricultural Science, Raichur, Karnataka between November 2022 and February 2023.

Methodology: Study included 52 powdery mildew differentials of sunflower studied factors such as genetic variability, heritability, and genetic advance in characters such as head diameter, seed filling percent, test weight, number of seeds per head, volume weight, oil content and seed yield. Correlation and path analysis was also done.

Results: Findings revealed significant differences among the traits, especially in seed yield per plant, head diameter, seed filling percent, test weight, and number of seeds per head which conclude that there is variability present in the studied character and there is scope for crop improvement. Correlation coefficients showed positive connections between seed yield per plant and traits like head diameter, test weight, seed filling percentage, and number of seeds per head. However, volume weight had a negative correlation. Path coefficient analysis helped us understand the direct and indirect impacts of these traits on seed yield per plant. Head diameter, seed filling percentage, test weight, and number of seeds per head had positive direct effects on seed yield per plant. In contrast, volume weight had a negative direct effect.

Conclusion: The study contributes to the understanding of the genetic architecture of sunflower traits related to yield and provides a foundation for developing targeted breeding strategies. These insights can guide sunflower breeding programs in selecting traits for improved yield.

Keywords: Sunflower, genetic variability, correlation, path analysis

1. INTRODUCTION

Sunflower (*Helianthus annuus* L.) holds a significant position in the world as a major oilseed crop which belongs to the genus *Helianthus*, encompassing 67 species (Fick, 1989). Renowned for its versatile utility, sunflower seeds contain 40-54 per cent oil and 16 per cent proteins. This oil, with its low saturated fatty acid content and elevated concentrations of polyunsaturated and monounsaturated fatty acids, is widely employed in various applications, from culinary use to the production of margarine and biodiesel. Beyond its culinary uses, sunflower oil has been acknowledged for its potential health benefits and its application as a dermo-protectant. Globally, sunflower is the second most cultivated oilseed crop, trailing only behind soybeans, while sunflower meal ranks third in oilseed meal consumption (Gangavati *et al.*, 2021; Pilorge, 2020).

Russia leads the world in sunflower seed production, followed by Ukraine, Russia and Argentina (Anon., 2020). In the context of India, sunflower production contributes 2.5 lakh tonnes, with Karnataka emerging as the leading producer, followed by Andhra Pradesh and Maharashtra (Anon., 2021-2022) with an area of 1.62 lakh ha. As yield is a complicated trait, its inheritance is dependent on several characters, many of which are polygenic in nature and heavily influenced by environmental variables. The correlation

HD (%)	12.16	0.39	2.83	5.52	17.82	22.58	22.67	99.24	5.64	46.42
SFP (%)	64.04	2.50	18.01	23.53	94.83	26.90	26.93	99.81	35.51	55.44
TW (g)	3.40	0.17	1.20	0.50	5.79	35.17	35.32	99.16	2.45	72.26
NSH	370.07	22.68	163.57	88.08	923.00	37.66	37.72	99.65	287.00	77.55
VW (g/100ml)	36.68	0.76	5.47	25.28	52.54	14.62	14.69	99.03	11.01	30.01
OIL (%)	31.87	0.41	2.98	25.68	40.71	8.30	8.40	97.64	5.39	16.92
YPP (g)	14.38	1.12	8.06	1.74	42.82	48.94	48.99	99.81	14.51	100.87

Note: HD- Head diameter (cm), NSH- Number of seeds per head, SFP- Seed filling percent (%), TW- Test weight (g), VW-Volume weight (g/100ml), OIL- Oil content (%), YPP- Seed yield per plant(g)

High heritability estimates were observed for all the characters studied. These results are in confirmatory with the findings of Supriya *et al.* (2016), Varalakshmi *et al.* (2020) and Shyam *et al.* (2021). This indicated that these characters were least influenced by the environment and generally, selection based on phenotypic observation would be effective. Heritability in conjunction with genetic advance would give more reliable index of selection value (Johanson *et al.*, 1955). A combination of high heritability and genetic advance was observed for seed yield per plant, head diameter, seed filling percent, test weight, number of seeds per head and volume weight which showed that these characters were amenable for improvement by phenotypic selection, particularly through mass selection (Ashok *et al.*, 2000). Such values of high heritability and genetic gain might contribute to additive gene effect. Thus, direct selection could be employed for improving these traits. These findings are consistent with Supriya *et al.* (2016) and Shyam *et al.* (2021). High heritability coupled with moderate genetic advance was observed for oil content indicating the prevalence of narrow range of variability suggesting that these characters could also be considered for improvement through selection as these were more likely to be controlled by additive gene action which aligns with the results of Supriya *et al.* (2016) and Varalakshmi *et al.* (2020).

Seed yield and oil content are two important characteristics in sunflower. It is desirable to evolve hybrids with high seed yield coupled with high oil per cent. High variability, heritability and genetic advance as percent of mean were observed for seed yield indicating additive gene action controlling the trait. While the character oil content showed low variability, high heritability and moderate genetic advance as per cent of mean.

The correlation coefficient between yield and yield attributing traits among them were estimated at phenotypic level. The phenotypic correlation coefficients between seed yield per plant and six contributing traits are given in table 3. Head diameter displayed a statistically significant positive correlation of 0.612 with test weight, 0.508 with seed filling percentage, and 0.468 with the number of seeds per head. Conversely, it exhibited a high and significant negative correlation of -0.461 with volume weight. These findings are consistent with prior research conducted by Baraiya *et al.* (2018), Riaz *et al.* (2019), Lakshman *et al.* (2021) and Gangavatiet *et al.* (2021). Hence, selecting for larger heads automatically leads to greater test weight and a higher number of filled seeds per head. However, it's important to note that head diameter showed a negative correlation with volume weight, so choosing larger heads may result in lower volume weight.

Table 3. Estimation of phenotypic correlation between seed yield and its component characters in sunflower powdery mildew differentials.

	HD	SFP	TW	NSH	VW	OIL	YPP
--	----	-----	----	-----	----	-----	-----

HD	1.000	0.508**	0.612**	0.468**	-0.461**	-0.044	0.601**
SFP		1.000	0.490	0.341*	0.574**	-0.275*	0.450**
TW			1.000	0.145	-0.348*	0.107	0.656**
NSH				1.000	-0.068	0.063	0.702**
VW					1.000	0.380**	0.340*
OIL						1.000	0.135
YPP							1.000

* Significant at 5 per cent ** Significant at 1 per cent

Note: HD- Head diameter (cm), NSH- Number of seeds per head, SFP- Seed filling percent (%), TW- Test weight (g), VW-Volume weight (g/100ml), OIL- Oil content (%), YPP- Seed yield per plant(g)

Seed filling per cent recorded significant positive correlation with head diameter (0.508) and number of seeds per head (0.340) at phenotypic level, these findings were in accordance with Ghodke *et al.* (2020). This indicates that a greater number of filled seed will automatically leads to larger heads and seeds with higher test weight. But as we go for genotypes with higher seed filling per cent it will leads to lower volume weighted seeds with low oil content. Whereastest weight demonstrated a strong and statistically significant positive correlation of 0.612 with head diameter and a significant positive correlation of 0.490 withseed filling percentage. Conversely, it showed a significant negative correlation of -0.348 with volume weight. Which indicates that seeds with higher test weight will automatically leads to large headed genotypes with high seed filling per cent. These findings are consistent with earlier research conducted by Chambóet *al.* (2016), Abu *et al.* (2019), Ghodke *et al.* (2020) and Gangavatiet *al.* (2021).

Number of seeds per head displayed a strong and statistically significant positive correlation of 0.468 with head diameter and a significant positive correlation of 0.341 with seed filling percentage. This highlights that opting for the selection of a greater number of seeds per head naturally leads to both increased head diameter and a higher number of filled seeds per head. These findings are consistent with previous research conducted by Pandya *et al.* (2015), Chambóet *al.* (2016) and Riaz *et al.* (2018). Oil content exhibited a strong and statistically significant positive correlation of 0.380 with volume weight, while it showed a significant negative correlation of -0.275 with seed filling percentage. Consequently, selecting lines with higher volume weight can result in lines with increased oil content. These findings are consistent with previous research conducted by Radić *et al.* (2013), Ghodke *et al.* (2020) and Gangavatiet *al.* (2021).

Volume weight displayed significant positive correlations with oil content (0.380) and seed filling percentage (0.574). Conversely, it exhibited a strong negative correlation with head diameter (-0.461). Therefore, selecting for higher volume weight proves to be an effective strategy for achieving greater seed filling percentage and oil content. These findings align with prior research conducted by Radić *et al.* (2013), Gangavatiet *al.* (2021) and Lakshman *et al.* (2021).

Path coefficient analysis, a statistical tool initially developed by Wright in 1921, serves as a valuable method for dissecting correlation coefficients into their direct and in direct effects on a dependent variable by independent variables. Dewey and Lu (1959) introduced a modified version of path coefficient analysis that offers a more practical foundation for assigning appropriate importance to various attributes when designing a realistic program for yield improvement. The results including phenotypic path coefficients are presented in Table 4.

Table 4. Estimation of phenotypic path co-efficients between seed yield and its component characters in sunflower powdery mildew differentials.

	HD	SFP	TW	NSH	VW	OIL	YPP
HD	-0.154	-0.078	-0.094	-0.072	0.071	0.007	0.601**
SFP	-0.074	-0.146	-0.072	-0.050	0.084	0.040	0.450**
TW	0.380	0.304	0.620	0.090	-0.216	0.066	0.656**
NSH	0.333	0.243	0.103	0.712	-0.049	0.045	0.702**
VW	0.120	0.149	0.090	0.018	-0.260	-0.099	0.340
OIL	-0.003	-0.021	0.008	0.005	0.029	0.075	0.135

Residual effect=0.392

Note: HD- Head diameter (cm), NSH- Number of seeds per head, SFP- Seed filling percent (%), TW- Test weight (g), VW-Volume weight (g/100ml), OIL- Oil content (%), YPP- Seed yield per plant(g)

Head diameter, with a negative direct effect of -0.154, had an adverse influence on seed yield per plant (0.601). These findings are consistent with the results reported by Abdelsatar *et al.* (2020) and Lakshman *et al.* (2021). Moreover, head diameter exhibited a positive in direct effect on seed yield per plant through test weight (0.380), the number of seeds per head (0.333) and volume weight (0.120). Conversely, it displayed a negative in direct effect through seed filling percentage (-0.074) and oil content (-0.003), which align with the findings of studies conducted by Baraiya *et al.* (2018), Riaz *et al.* (2019) and Lakshman *et al.* (2021). This result indicates that head diameter has a direct affect in seed yield of the plants in a negative manner but it indirectly affects seed yield per plant positively via test weight, number of seeds per head and volume weight.

Seed filling percentage, with a negative direct effect of -0.146, exhibited a detrimental impact on seed yield per plant (0.450), which is consistent with the findings reported by Lakshman *et al.* (2021). Furthermore, this particular trait demonstrated a positive in direct effect on seed yield per plant through test weight (0.304), volume weight (0.149) and the number of seeds per head (0.243). However, it displayed a negative in direct effect through head diameter (-0.078) and oil content (-0.021), findings that are in line with the results from studies conducted by Sowmya *et al.* (2010), Lakshman *et al.* (2018) and Shyam *et al.* (2021). This indicates that seed filling per cent has a negative direct effect on seed yield per plant and it has a positive in direct effect on seed yield via test weight, volume weight and the number of seeds per head.

Test weight, with a direct effect of 0.620, displayed a positive impact on seed yield per plant (0.656). These findings are in line with previous studies conducted by Sowmya *et al.* (2010), Shyam *et al.* (2021) and Lakshman *et al.* (2021). Furthermore, this trait exhibited positive in direct effects on seed yield per plant through the number of seeds per head (0.103), volume weight (0.090), and oil content (0.008). Conversely, it showed an in direct negative effect on seed yield per plant through head diameter (-0.94) and seed filling percentage (-0.072). These indirect effects are consistent with the results reported in studies conducted by Lakshman *et al.* (2018), Arshad *et al.* (2019), Abdelsataret *et al.* (2020) and Lakshman *et al.* (2021). Which gives an information that test weight shows a direct effect on seed yield and it indirectly affects the seed yield positively via number of seeds per head, volume weight and oil content.

The number of seeds per head, with a direct effect of 0.712, exhibited a positive impact on seed yield per plant (0.702). These findings are consistent with those reported in studies by Baraiya *et al.* (2018), Lakshman *et al.* (2018) and Lakshman *et al.* (2021). Additionally, this trait demonstrated a positive in direct effect on seed yield per plant through volume weight (0.018), test weight (0.090) and oil content (0.005). Conversely, it displayed a negative in direct effect through head diameter (-0.072) and seed filling percentage (-0.050). These in direct effects align with the results reported in studies conducted by Baraiya *et al.* (2018), Riaz *et al.* (2019), Abdelsataret *et al.* (2020), Lakshman *et al.* (2021)

and Shyam *et al.* (2021). This gives us a picture that number of seeds per head directly impact seed yield per plant in a positive manner and indirectly it impacts via volume weight, test weight and oil content.

The oil content, with a direct effect of 0.075, had a positive influence on seed yield per plant (0.135), which is consistent with findings from previous studies conducted by Sowmya *et al.* (2010), Lakshman *et al.* (2018) and Arshad *et al.* (2019). Moreover, this trait exhibited positive in direct effects on seed yield per plant through head diameter (0.007), seed filling percentage (0.040), test weight (0.066) and the number of seeds per head (0.045). Conversely, it displayed an indirect negative effect on seed yield per plant through volume weight (-0.099), which is in line with results reported in studies conducted by Sowmya *et al.* (2010), Arshad *et al.* (2019), Riaz *et al.* (2019) and Gangavati *et al.* (2021). This tells us that oil content has a direct impact on seed yield per plant and it shows an indirect impact on seed yield per plant positively through head diameter, seed filling percentage, test weight, and the number of seeds per head.

The volume weight, with a direct effect of -0.026, had a negative impact on seed yield per plant (-0.340). This finding aligns with previous studies conducted by Binod *et al.* (2008) and Lakshman *et al.* (2021). Additionally, this particular trait exhibited positive in direct effects on seed yield per plant through head diameter (0.071), seed filling percentage (0.084) and oil content (0.029). Conversely, it showed indirect negative effects on seed yield per plant through test weight (-0.216) and the number of seeds per head (-0.049). These results are consistent with the findings of other studies conducted by Gangavati *et al.* (2021), Ghodke *et al.* (2021) and Lakshman *et al.* (2021). Therefore, volume weight directly affects seed yield per plant negatively and indirectly via head diameter, seed filling percentage and oil content positively.

In the current study, the residual effect observed was 0.392, signifying its significance in measuring the influence of unexamined independent variables on the dependent variable at the phenotypic level. This study highlights that there is a combined impact of both direct and indirect effects, accounting for 0.392 in total. However, it is advisable to consider the inclusion of additional component variables to enhance the accuracy and reliability of the path analysis in assessing both direct and indirect effects at the phenotypic level. Furthermore, it's worth noting that a moderate level of residual effects in the present study can still contribute valuable insights for drawing genetic conclusions based on the interplay of direct and indirect effects.

4. CONCLUSION

In conclusion, the study revealed that several traits, including seed yield per plant, number of seeds per head, 100-seed weight, seed filling percent, head diameter, and volume weight, exhibit high heritability and significant potential for improvement through selection. The positive correlations between seed yield and the number of seeds per head, 100-seed weight, and head diameter further highlight the importance of these traits in achieving higher sunflower yields. Path coefficient analysis reinforced the central role of the number of seeds per head in directly influencing seed yield per plant. These findings provide valuable guidance for sunflower breeding programs, emphasizing the need to prioritize traits such as the number of seeds per head, head diameter, and seed filling percent for achieving improvements in yield. The study contributes to the understanding of the genetic architecture of sunflower traits related to yield and provides a foundation for developing targeted breeding strategies. Further research and validation of these findings across diverse environments and genotypes will be crucial for the successful implementation of breeding programs aimed at enhancing sunflower productivity.

REFERENCES

1. Fick GN, Zimmer DE and Zimmerman DC. Correlation of seed oil content in sunflower with other plant and seed characteristics. *Crop Sci.*, 1974;14: 755-775.
2. Gangavati L and Kulkarni VV. Correlation and Path Analysis in Advanced Inbred Lines of Sunflower. *Int. J. Curr. Microbiol. App. Sci.*, 2021; 10(01): 1381-1389.

3. Pilorgé E. Sunflower in the global vegetable oil system: situation, specificities and perspectives. OCL., 2020; 27: 34.
4. Anonymous, 2022a. Area, production and productivity of sunflower. Food and Agricultural Organisation, Rome, Italy. Available:<https://www.fao.org/3/cc2211en/cc2211en.pdf>
5. Anonymous, 2022b. Area, production and productivity of sunflower, Available:www.indiastat.com/data/agriculture/agricultural-area-land-use
6. Federer WT. Experimental Design: Theory and application. McMillan, New York; 1977.
7. Johnson HW, HF Robinson and RE Comstock. Estimates of genetic and environmental variability in soybeans. Agron. J., 1955; 47: 314-318.
8. Dewey DI and Lu KH. A correlation and path-coefficient analysis of components of crested wheatgrass seed production. Agron. J., 1959; 51: 515-518.
9. Sudrik, BP, Ghodke MK, Patil VS, Chavan SK and Kesale NB. Evaluation and characterisation of sunflower (*Helianthus annuus* L.) germplasm. J. Crop Weed., 2014; 10(1): 73-76.
10. Baraiya, VK, Jagtap PK, Sangani JL and Malviya AV. Correlation and path analysis in sunflower (*Helianthus annuus* L.). J. Pharmacog. Phytochem., 2018; 7(5): 2730-2732.
11. Varalakshmi K, Neelima S, Reddy RN and Sreenivasulu KN. Genetic variability studies for yield and its component traits in newly developed sunflower (*Helianthus annuus* L.) hybrids. Electron. J. Plant Breed., 2020; 11(01): 301-305.
12. Supriya SM, Kulkarni Vikas V, Goud I Shanker, Lokesh R and Govindappa MR. Genetic variability studies for yield and yield components in sunflower (*Helianthus annuus* L.), Electron. J. Plant Breed. 2016; 7 (3): 737-741.
13. Reavanth T, Manivannan N, Sasikala R and Rajendran L. Genetic Variability and Association Analysis for Yield and Its Component Traits in Sunflower (*Helianthus annuus* L.). Madras Agric. J., 2022; 109(10-12): 1.
14. Shyam SL, Chakraborty NR, Debnath S and Kant A. Genetic variability, character association and divergence studies in sunflower (*Helianthus annuus* L.) for improvement in oil yield. African J. Bio. Sci., 2021; 3(1): 129-145.
15. Riaz A, Nadeem Tahir MH, Rizwan M, Fiaz S, Chachar S, Razzaq K, Riaz, B and Sadia H. Developing a selection criterion using correlation and path coefficient analysis in sunflower (*Helianthus annuus* L.). Helia, 2019; 42(70): 85-99.
16. Lakshman SS, Chakraborty NR, Debnath S and Kant A. Genetic variability, character association and divergence studies in sunflower (*Helianthus annuus* L.) for improvement in oil yield. Afr. J. Biol. Sci., 2021; 3(1): 129-145.
17. Sowmya HC, Shadakshari YG, Pranesh KJ, Srivastava A and Nandini B. Character association and path analysis in sunflower (*Helianthus annuus* L.). Electron. J. Plant Breed., 2010; 1(4): 828-831.
18. Ghodke GNM. Correlation and path analysis studies in multihead inbred lines of sunflower (*Helianthus annuus* L.). J. Pharmacog. Phytochem., 2021; 10(1): 707-709.

19. Chambó, ED, Escocard de Oliveira NT, Garcia RC, Ruvolo-Takasusuki MCC and de Toledo VDAA. Phenotypic correlation and path analysis in sunflower genotypes and pollination influence on estimates. Open Biol. Sci. J., 2017; 3(1): 9-15.
20. Abu EM. Genetic variability and character association in sunflower (*Helianthus annuus* L.) genotypes in central highlands of Ethiopia. M.Sc. (Agri.) Thesis, JIMMA Uni., Ethiopia. 2019;
21. Pandya, MM, Patel PB and Narwade AV. A study on correlation and path analysis for seed yield and yield components in sunflower (*Helianthus annuus* L.) Electron. J. Plant Breed.,2015; 6(2): 540-54.
22. Radić, V, Mrđa J, Terzić S, Dedić B, Dimitrijević A, Balalić I and Miladinović D. Correlations and path analyses of yield and other sunflower seed characters. Genetika-Belgrade, 2013; 45(2): 459-466.
23. Lakshman,SS. Studies on Character association for yield and yield attributing components in Sunflower (*Helianthus annuus* L.) germplasms in coastal saline belts of West Bengal. Int. J. Sci. Res. Sci. Technol, 2018; 4(8): 289-295.
24. Arshad M, Jan S, Awan S, Azam S, Khalid S and Khan MA. Investigation of genetics divergence in newly developed local sunflower (*Helianthus annuus* L.) hybrids. Pak. J. Agric. Res., 2019; 32(1): 33-40.
25. Abdelsatar MA, Ahmed AAEH and Ibrahim SELK. Genetic variability and selection criteria of some sunflower genotypes under different pollination methods. Acta Agric. Slov., 2020; 116(1): 35-47.