International Journal of Plant & Soil Science

34(18): 228-235, 2022; Article no.IJPSS.86954
ISSN: 2320-7035

Correlation and Path Analysis in Sesame (*Sesamum indicum* L.) Genotypes

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Authors' contributions

This work was carried out in collaboration between both authors. Author KS designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and analyzed the study. Author MKG managed the literature searches and both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i1831075

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86954

Original Research Article

Received 03 March 2022
Accepted 07 May 2022
Published 11 May 2022

ABSTRACT

Aims: Evaluation of correlation between yield and yield contributing traits in Sesame, as well as to determine their direct and indirect effects on fruit yield of sesame genotypes.
Study Design: Randomized block design (RBD) with two replications.
Place and Duration of Study: Oilseeds Research Station, Department of genetics and plant breeding, College of Agriculture, VNMKV, Latur (MS), between July 2016 and January2017.
Methodology: For statistical analysis mean values are used. SPSS version 17.0 and GENRES were used to perform the correlation and path analysis using Sixty five accessions and evaluated for the following eleven traits: days to 50% flowering (D50%), days to maturity (DM**)**, capsule length (CL**)**, capsule width (CW**)**, plant height (PH), number of branches per plant (NBP),number of capsules per plant (NCP),number of seeds per capsule (NSC),1000-seed weight (1000SW), oil content (OC), seed yield per plant (SYP).
Results: The correlation analysis indicated that CL (0.237), PH (0.225), NCP (0.806), NSC (0.372), 1000SW (0.657) and OC (0.532) positively correlated with seed yield at genotypic as well as phenotypic levels, respectively. Path coefficient analysis indicated that NCP (0.746), 1000SW (0.356), OC (0.007), NSC (0.267), CL (0.0608) and PH (0.034) exhibited positive direct effect on seed yield.

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Conclusion: Positive indirect effect was observed by both DM, NBP has expressed positive and indirect effect on yield *via* their component traits. Selection among genotypes based on these analyses can be made for further improvement in fruit yield and component characters

Keywords: Sesame; correlation; path analysis; direct and indirect effects; selection.

ABBREVIATIONS

D50%	:	*Days to 50% Flowering*
DM	:	*Days to Maturity*
CL	:	*Capsule Length*
CW	:	*Capsule Width,*
PH	:	*Plant Height,*
NBP	:	*Number of Branches per Plant,*
NCP	:	*Number of Capsules per Plant,*
NSC	:	*Number of Seeds per Capsule,*
1000SW	:	*1000-seed Weight,*
OC	:	*Oil Content,*
SYP	:	*Seed Yield per Plant.*

1. INTRODUCTION

Sesame (*Sesamum indium* L.) is an old and traditional oilseed crop grown for its high-quality oil in India. Yield is a polygenetically regulated trait that is heavily impacted by environmental factors. Selection just on the basis of yield is ineffective. Selection based on its components improves yield since they albeit less complicated, but also more easily inherited and less affected by environmental variations. Path co-efficient analysis is a useful tool for breaking down the correlation coefficient into effects of the component characters. Selection based on effects is far more beneficial than selection for yield per se alone.

India is a depository for various sesame genotypes with varied genetic characters ranging from black to white colored seed coat and oil content, suitable for all cropping seasons. In order to develop effective breeding programs, study of the correlation between yield and its components, as well as their respective contributions to yield is crucial. Path coefficient analysis is another useful method for better understanding crop heredity in terms of yield. It provides specific measures of each component character's direct and indirect influence on yield. Using correlation and path analysis of yield and yield contributing characters of sixty-five sesame accessions identified in India, the current study was done to identify characters that influences seed yield.

2. MATERIALS AND METHODS

The field experiment of the present study was carried out at oil seeds research station, Latur during *kharif 2016*. Sixty-five accessions (Table 1) were raised during July, 2016 in randomized block design (RBD) with two replications. The 65 sesame genotypes were sown on 1st July, 2016 with two replications in a Randomized Block Design. Each genotype in each replication was sown by dibbling the seeds in a single row plot of 9.0 m length, with 45 cm row spacing and 10 cm hill spacing. Thinning of seedlings was carried out after 10 days of sowing by keeping one seedling per hill. The recommended cultural practices were adopted in respect of irrigation, weeding and fertilization. Plant protection measures were taken up as and when required. The genotypes were harvested as and when they attained physiological maturity.

2.1 Statistical Analysis

The mean values were utilized for statistical analysis. The correlation and path analysis was performed by using the software SPSS version17.0 and GENRES.

3. RESULTS

The observations recorded on sixty-five accessions for eleven characters viz., Days to 50% flowering (D50%),days to maturity (DM), capsule length (CL), capsule width (CW),plant height (PH),number of branches per plant (NBP),number of capsules per plant NCP),number of seeds per capsule (NSC),1000-seed weight (1000SW), oil content (OC),seed yield per plant(SYP) were analyzed statistically for genetic parameters and character association among them was presented hereunder.

Seed yield is a complicated characteristic that is seen as the sum of its parts. a plant is a visible integrated structure, in which most of the traits are inter-connected and influenced by a larger number of genes(Lule et al.,2012), selecting superior genotypes based on seed yield is challenging. The inter-relationship of yield component characters provides an idea for the selection and simultaneous improvement of desirable yield contributing characters. Hence, correlation studies were conducted to determine the association between seed yield and its component characteristics.

The genotypic correlation coefficients between yield and its component character and inter correlation among the traits were presented in the Table 2. seed yield per plant (SYP) exhibited positive significant correlation with number of capsules per plant (NCP) (0.806), 1000-seed weight (1000SW) (0.657), oil content (OC) (0.532), number of seeds per capsule (NSC) (0.372), capsule length (CL) (0.237) and plant height (PH) (0.225) while capsule width(CW) (0.086) and days to 50% flowering (D50%) shown non-significant correlation with seed yield per plant (SYP) and negative non-significant correlation with days to maturity (DM) (-0.122) and number of branches per plant (NBP) (-0.041) at both genotypic and phenotypic levels.

3.1 Path Analysis

The genetic architecture of seed yield is a result of balance or overall net effect created by various yield components interacting with one another. Since, Correlation is not a reliable tool as it cannot be considered as causation, for instance there is a correlation between sunrise and rooster crowing. But, rooster crow does not cause sunrise. Thus, total correlation between yield and its component characters may be some times misleading, as it might be an over-estimate or under-estimate because of its association with other characters. Therefore it is important to reveal cause effects of yield attributing characters towards yield. Path analysis provides a route map of yield attributing characters that effects yield; it divides correlation into direct and indirect effects. In this study splitting total correlation into direct and indirect effect of cause using statistical design devised by Wright [1] and computed by Deway and Lu [2] would provide more meaningful interpretation. The direct and indirect effects of different yield contributing traits on yield were estimated using following genotypic and phenotypic correlation coefficients formula,

Genotypic correlation:

$$\mathrm{rg\,(xy)} = \frac{Cov^{g}(xy)}{\sqrt{\sigma^{2}\,\mathrm{g(x)}}\,\sqrt{\sigma^{2}\,\mathrm{g(y)}}}$$

Where,

r_g (xy)= Genotypic correlation between ‘x’ and ‘y’
Cov_g (xy) = Genotypic covariance between character ‘x’ and ‘y’

σ^2 g(x) = Genotypic variance of ‘x’
σ^2 g(y) = Genotypic variance of ‘y’

Phenotypic correlation:

$$\mathrm{rg\,(xy)} = \frac{Cov^{p}(xy)}{\sqrt{\sigma^{2}\,\mathrm{p(x)}}\,\sqrt{\sigma^{2}\,\mathrm{p(y)}}}$$

Where,
r_p (xy)= Phenotypic correlation between ‘x’ and ‘y’
Cov_p (xy) = Phenotypic covariance between character ‘x’ and ‘y’

σ^2 p(x) = Phenotypic variance of ‘x’
σ^2 p(y) = Phenotypic variance of ‘y’

And, genotypic and phenotypic correlation coefficients are presented in Table 3.

Direct effects: Days to 50% flowering (D50%) (0.0082), capsule length (CL) (0.0608), capsule width (CW) (0.028), plant height (PH) (0.034), number of capsules per plant (NCP) (0.746), number of seeds per capsule (NSC) (0.267), 1000 seed weight (1000SW) (0.356), oil content (OC) (0.0078) exhibited positive direct effect on seed yield, whereas negative direct effect was observed for days to maturity (DM) (-0.0229) and number of branches per plant (NBP) (-0.107).

Indirect effects: Maximum positive indirect effect was exerted by number of capsules per plant (NCP) via plant height (PH) (0.233) followed by oil content (OC) (0.229). 1000 seed weight (1000SW) exerted maximum positive indirect effect via oil content (OC) (0.209) followed by number of capsules per plant (NCP) (0.099). Oil content (OC) exerted positive indirect effect via 1000-seed weight (1000SW) (0.0046) followed by number of capsules per plant (NCP) (0.0024), number of seeds per capsule (NSC) exerted maximum positive indirect effect via capsule length (CL) (0.160) followed by capsule width (CW) (0.128).

4. DISCUSSION

Present study revealed that the traits viz., number of capsules per plant (NCP), 1000-seed weight (1000SW), oil content (OC), number of seeds per capsule (NSC), capsule length (CL) and plant height (PH) exhibited significant positive character association with seed yield per plant (SYP) at both phenotypic and genotypic levels. The results are in consonance with the earlier reports of, Saipriya et al*.* [3], Hukumchand and parameshwarappa [4] and Kehie et al*.* [5] for capsule length (CL) and 1000 seed weight (1000SW). For oil content (OC) Kehie*et al.* [5] reported positive correlation with seed yield. Saipriya et al*.* [3], Ramparasad et al*.* [6] have reported positive association of plant height (PH) with seed yield. Bhagwath singh and Rjani bisen [7] and Ramparasad et al*.* [6] reported positive association of number of capsules per plant (NCP) with seed yield. Saipriya et al*.* [3] and Manjeet et al*.* [8] have also reported positive significant correlation of seed yield with number of seeds per capsule (NSC). As a nutshell, these characteristics should keep in view to improve seed yield per plant (SYP) using them in selection criteria.

Seemingly and definitely the number of capsules per plant (NCP) directly contributes to yield i.e., more number of capsules leads to more seed yield. This character exhibited the highest direct positive effect and indirect effect through other characters 1000-seed weight (1000SW) and plant height (PH). Since this trait has a strong correlation and direct effect on seed yield per plant, selecting for this trait may greatly contributes to seed yield per plant. These results are in agreement with Abate and Mekbib [9],

Table 1. Details of sixty-five genotypes of sesame

S.No	Genotype	Source	S. No	Genotype	Source
1	SI-413-A	P.C. Unit, Jabalpur.	34	IC-42200	P.C. Unit, Jabalpur.
2	SI-205-61	P.C. Unit, Jabalpur.	35	IC-23233	P.C. Unit, Jabalpur.
3	SI-199-2-84	P.C. Unit, Jabalpur.	36	NIC-16220	P.C. Unit, Jabalpur.
4	SI-1147	P.C. Unit, Jabalpur.	37	EC-231-2-84	P.C. Unit, Jabalpur.
5	IS-299A	P.C. Unit, Jabalpur.	38	EC-370840	P.C. Unit, Jabalpur.
6	ES-44	P.C. Unit, Jabalpur.	39	EC-209	P.C. Unit, Jabalpur.
7	ES-146-1-84	P.C. Unit, Jabalpur.	40	EC-89111	P.C. Unit, Jabalpur.
8	ES-113-18-84	P.C. Unit, Jabalpur.	41	EC-377015	P.C. Unit, Jabalpur.
9	EC-370936	P.C. Unit, Jabalpur.	42	SI-983	P.C. Unit, Jabalpur.
10	IC-204001	P.C. Unit, Jabalpur.	43	OSC-3209	P.C. Unit, Jabalpur.
11	GM-NIC- 7909	P.C. Unit, Jabalpur.	44	DS-21	P.C. Unit, Jabalpur.
12	GM-NIC- 7913	P.C. Unit, Jabalpur.	45	EC-101396	P.C. Unit, Jabalpur.
13	GM-NIC- 8202	P.C. Unit, Jabalpur.	46	SI-5354	P.C. Unit, Jabalpur.
14	GM-NIC- 8631	P.C. Unit, Jabalpur.	47	IS-424	ORS, Latur.
15	GM-NIC- 8934	P.C. Unit, Jabalpur.	48	SI-3168	ORS, Latur.
16	GM-NIC- 16146	P.C. Unit, Jabalpur.	49	KMR-69	ORS, Latur.
17	GM-NIC- 16226	P.C. Unit, Jabalpur.	50	KMR-114	ORS, Latur.
18	GM-NIC- 16330	P.C. Unit, Jabalpur.	51	GT-3	ORS, Latur.
19	GM-NIC- 16332	P.C. Unit, Jabalpur.	52	SI-1003	ORS, Latur.
20	GM-NIC- 8254	P.C. Unit, Jabalpur.	53	YLM-17	ORS, Latur.
21	NIC-7855	P.C. Unit, Jabalpur.	54	EC-303423	ORS, Latur.
22	NIC-7903	P.C. Unit, Jabalpur.	55	PKDS-8	ORS, Latur.
23	NIC-10621	P.C. Unit, Jabalpur.	56	JLT-07	ORS, Latur.
24	NIC-16114	P.C. Unit, Jabalpur.	57	TKG-22	ORS, Latur.
25	NIC-16324	P.C. Unit, Jabalpur.	58	EC-S-0523A	ORS, Latur.
26	NIC-16104	P.C. Unit, Jabalpur.	59	EC-S-0223	ORS, Latur.
27	NIC-8263	P.C. Unit, Jabalpur.	60	TKG-306	ORS, Latur.
28	EC-310439	P.C. Unit, Jabalpur.	61	IS-207	ORS, Latur.
29	ES-42-2-84	P.C. Unit, Jabalpur.	62	JLT-408	ORS, Latur.
30	K-5170	P.C. Unit, Jabalpur.	63	MADURI	ORS, Latur.
31	UKNM-1067	P.C. Unit, Jabalpur.	64	G-1	ORS, Latur.
32	UKNM-2386	P.C. Unit, Jabalpur.	65	SWETA	Local selection from Telangana
33	IC-41962	P.C. Unit, Jabalpur.			

Table 2. Phenotypic (P) and Genotypic (G) correlation coefficients among yield attributes in 65 sesame genotypes

Character		DF 50%	DM	CL (cm)	CW (cm)	PH (cm)	NBP	NCP	NSC	1000 SW (g)	OC (%)	SYP (g)
DF 50%	G	**1.0000**	0.6479**	0.2029*	0.0434	0.1708	-0.1128	-0.0247	0.1629	-0.0217	0.1433	0.0434
	P	**1.0000**	0.6305**	0.1769*	0.0504	0.1373	-0.0870	-0.0393	0.1538	-0.0054	0.0979	0.0350
DM	G		**1.0000**	0.2204*	0.1203	0.3166**	0.0815	-0.2138	0.1353	-0.0039	0.0838	-0.1226
	P		**1.0000**	0.1995*	0.1160	0.2751**	0.0783	-0.2076	0.1160	-0.0120	0.0643	-0.1308
CL (cm)	G			**1.0000**	0.2720**	0.0597	-0.1412	-0.0835	0.6020**	0.1575	0.1127	0.2378**
	P			**1.0000**	0.2277**	0.0548	-0.1300	-0.0640	0.5319**	0.1322	0.1025	0.2189*
CW (cm)	G				**1.0000**	-0.0043	-0.0646	-0.1538	0.4830**	0.0640	0.0372	0.0864
	P				**1.0000**	-0.0338	-0.0612	-0.0961	0.3685**	0.0508	0.0340	0.0843
PH (cm)	G					**1.0000**	0.5133**	0.3128**	0.0030	0.0273	0.1320	0.2225*
	P					**1.0000**	0.4726**	0.2832**	-0.0233	0.233	0.1241	0.1986*
NBP	G						**1.0000**	0.2232*	-0.2762**	-0.0861	-0.0914	-0.0411
	P						**1.0000**	0.2162*	-0.2501**	-0.0678	-0.0884	-0.0262
NCP	G							**1.0000**	-0.0875	0.2780**	0.3070**	0.8065**
	P							**1.0000**	-0.0975	0.2378**	0.2739**	0.7935**
NSC	G								**1.0000**	0.2548**	0.2412**	0.3726**
	P								**1.0000**	0.2864**	0.2164*	0.3812**
1000SW (g)	G									**1.0000**	0.5885**	0.6578**
	P									**1.0000**	0.5512**	0.6437**
OC (%)	G										**1.0000**	0.5325**
	P										**1.0000**	0.4941**
SYP (g)	G											**1.0000**
	P											**1.0000**

** and ** = significant at 5%, and 1% level respectively*

Table 3. Phenotypic (P) and Genotypic (G) Path coefficients among yield attributes in 65 sesame genotypes

Characters		DF 50%	DM	CL (cm)	CW (cm)	PH (cm)	NBP	NCP	NSC	1000 SW(g)	OC (%)	Correlation with SYP (g)
DF 50%	G	**0.0082**	0.0053	0.0017	0.0004	0.0014	-0.0009	-0.0002	0.0013	-0.0002	0.0012	0.0434
	P	**0.0183**	0.0115	0.0032	0.0009	0.0025	-0.0016	-0.0007	0.0028	-0.0001	0.0018	0.0350
DM	G	-0.0148	**-0.0229**	-0.0050	-0.0028	-0.0072	-0.0019	0.0049	-0.0031	0.0001	-0.0019	-0.1226
	P	-0.0201	**-0.0318**	-0.0063	-0.0037	-0.0087	-0.0025	0.0066	-0.0037	0.0004	-0.0020	-0.1308
CL	G	0.0123	0.0134	**0.0608**	0.0165	0.0036	-0.0086	-0.0051	0.0366	0.0096	0.0069	0.2378**
	P	0.0081	0.0091	**0.0457**	0.0104	0.0025	-0.0059	-0.0029	0.0243	0.0060	0.0047	0.2189*
CW	G	0.0012	0.0034	0.0077	**0.0283**	-0.0001	-0.0086	-0.0051	0.0366	0.0096	0.0069	0.0864
	P	0.0008	0.0018	0.0035	**0.0156**	-0.0005	-0.0010	-0.0015	0.0057	0.0008	0.0005	0.0843
PH	G	0.0060	0.0111	0.0021	-0.0002	**0.0349**	0.0179	0.0109	0.0001	0.0010	0.0046	0.2225*
	P	0.0046	0.0092	0.0018	-0.0011	**0.0334**	0.0158	0.0095	-0.0008	0.0008	0.0041	0.1986*
NBP	G	0.0121	-0.0087	0.0151	0.0069	-0.0551	**-0.1073**	-0.0240	0.0296	0.0092	0.0098	-0.0411
	P	0.0080	-0.0072	0.0120	0.0056	-0.0435	**-0.0921**	-0.0199	0.0230	0.0062	0.0081	-0.0262
NCP	G	-0.0185	-0.1595	-0.0623	-0.1148	0.2334	0.1666	**0.7462**	-0.0653	0.2075	0.2291	0.8065**
	P	-0.0292	-0.1541	-0.0475	-0.0714	0.2103	0.1605	**0.7424**	-0.0723	0.1765	0.2033	0.7935**
NSC	G	0.0435	0.0361	0.1607	0.1289	0.0008	-0.0737	-0.0234	**0.2670**	0.0680	0.0644	0.3726**
	P	0.0456	0.0344	0.1575	0.1091	-0.0069	-0.0741	-0.0289	**0.2961**	0.0848	0.0641	0.3812**
1000 SW (g)	G	-0.0077	-0.0014	0.0561	0.0228	0.0097	-0.0307	0.0990	0.0908	**0.3562**	0.2096	0.6578**
	P	-0.0020	-0.0043	0.0480	0.0185	0.0084	-0.0246	0.0863	0.1040	**0.3630**	0.2001	0.6437**
OC (%)	G	0.0011	0.0007	0.0009	0.0003	0.0010	-0.0007	0.0024	0.0019	0.0046	**0.0078**	0.5325**
	P	0.0009	0.0006	0.0010	0.0003	0.0012	-0.0008	0.0026	0.0020	0.0051	**0.0093**	0.4941**

Genotypic residual effect = 0.1671

Saipriya et al. [3], Hukumchand and parameshwarappa [4] and Kehie et al. [5]. 1000-seed weight (g) (1000SW) exhibited a considerable amount of direct effect on seed yield per plant at both genotypic and phenotypic levels. Positive direct effect of this trait was also reported by Aye and htwe (2019), Hukumchand and parameshwarappa [4] and Labhya Rani and Sharma [10]. Capsule length (CL) also exhibited fair amount of direct effect and is correlated positively significant with seed yield per plant, these results are in harmony with the reports of Bhagwath singh and Rjani bisen [11], Ramparasad et al. [6] and Kehie*et al.* [5]. Plant height (PH) definitely influences seed yield per plant by offering space for more number of branches (NBP) and thus more number of capsules and this character exhibited positive direct effect. These results are in consonance with Bhagwath singh and Rjani bisen [7] and Ramparasad et al. [5]. Capsule width (CW) offers more room for seed filling that in further influences seed yield, this trait has exhibited positive direct effect. These results are in agreement with Bamrotiya et al. [11]. However, Aye and htwe [12] reported positive indirect effect of this trait with seed yield. Days to 50% flowering (D50%) influenced seed yield per plant by low positive direct effect at both levels. These results are in agreement with Labhya Rani and Sharma [10] and Manjeet et al. [8]. Oil content (OC) influenced seed yield plant^{-1} by low positive direct effect at both levels. These results are in accordance with Bhagwath singh and Rjani bisen [11] and Kehie*et al.* [5]. Number of seeds per capsule (NSC) directly influences the yield this character shown positive direct effect with seed yield and similar reports were obtained by Ramparasad et al. [6] and Kehie et al. [5]. Days to maturity (DM) influenced seed yield per plant negatively direct effect at both levels. The similar reports were reported by Abate and Mekbib [9] and Ramparasad et al. [6] at phenotypic level. Number of branches per plant (NBP) also showed negative direct effect on seed yield at both levels, these results are in congruence with Saipriya et al. [3] and Hukumchand and parameshwarappa [4].

The results indicated those characters with positive correlation have shown high direct effects. Hence, number of capsules (NCP), 1000-seed weight (1000SW), oil content (OC), number of seeds per capsule (NSC), capsule length (CL) and plant height (PH) has high direct and correlation values.

The residual effect from path analysis was 0.167, which indicated the adequacy of the characters chosen for the study and the characters studied contributed about 81.3 percent towards seed yield (SY). The results of path analysis study affirm that the characters like number capsules per plant (NCP), capsules length (CL), number of seeds per capsule (NSC), 1000 seed weight (1000SW), oil content (OC) were most important yield determinants, because of their high direct effects via many other yield improving characters and indirect contribution of these characters towards the yield is negligible [13]. This suggests that emphasis must be given on such traits while exercising selection to improve the yield in sesame.

5. CONCLUSION

Correlation studies indicated that capsule length (CL), plant height (PH), number of capsules (NCP), number of seeds (NSC), 1000-seed weight (1000SW) and oil content (OC) (%) except days to 50% flowering (D50%) and capsule width (CW) had significant positive association with seed yield.

Path coefficient analysis revealed that high positive direct effect of number of capsules (NCP), number of seeds (NSC), 1000-seed weight (1000SW) and capsule length (CL) with seed yield (SY). Therefore, simultaneous selection for the said traits is suggested for improvement of seed yield in sesame.

ACKNOWLEDGEMENT

The authors would like to acknowledge the VNMKV University and Oilseeds research station, Latur staff for their extended support and ICAR.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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