Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(3): 1674-1678
Received: 06-03-2020
Accepted: 10-04-2020

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The association and path coefficient analysis for yield and yield attributing traits in sesame (*Sesamum indicum* L.)

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Abstract
This trial conducted on twenty seven elite lines were used for the studies of correlation and path coefficient analysis with twelve yield and attributing traits. The experiment was operated at Agriculture Farm, Nana Ji Deshmukh New Agriculture Campus, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (M.P.). The field lay out was done in Randomized Block Design with 3 replications. Correlation coefficient for seed yield (kg/ha) revealed that highly significant and positive association with seed yield per plot and number of seeds per capsule. The direct effect on dependent variable (seed yield (kg/ha)) showed highly positive and significant by No. of seeds / capsule (0.661) followed by No. of capsules / plant (0.524), Oil content (0.181) and 1000 seed weight (0.117). The highest positive and direct effect on seed yield per plot at phenotypic level was recorded by No. of capsules per plant (0.148). therefore, selection of these characters would be effective for further breeding purpose of sesame.

Keywords: Sesame, correlation, path analysis

Introduction
Sesame (*Sesamum indicum* L.) seeds and its oil are being utilized as important food ingredients since about 6000 year. The name sesame, derives from the Arabic word "simsim". Sesame (*Sesamum indicum* L.) also known as Til or Gingelly. The oldest Indian testament *viz.* Vedic scriptures (ca.1000 B.C.) contain frequent references to sesame. It was cultivated during ancient Harappan, Mesopotamian, and Anatolian eras, and throughout the Graeco-Roman world, both for its edible seed and oil.

It is one of the most important oilseed crop of tropical and temperate regions. It is referred as "Queen of oilseeds" due to its resistance to oxidation and rancidity, also plays an important role as an industrial food crop because of its high nutritional value. The seeds of sesame contains (40 to 63% oil and 25% protein) which is rich in antioxidants and has a significant amount of oleic and linoleic acids (Abate and Mekbib, 2015) [1]. Sesame seed is consumed as a source of calcium, potassium, tryptophan and methionine. Sesame oil has highest antioxidant content and contains several fatty acids such as oleic acid (43%), linoleic acid (35%), palmitic acid (11%) and stearic acid (7%).

Sesame (*Sesamum indicum* L.) belongs to the family Pedaliaceae, a diploid species with (2n = 26). Sesame is an important oilseed crop successfully grown in tropical and sub-tropical climates. Sesame (*Sesamum indicum* L.) is grown throughout the subtropical regions of the world covering about more than 55 countries. Asia contributes more than 68 percent of total area and 67 percent of total production of the world. India is the largest producer of sesame in the world, accounting for 31 percent of the world acreage and contributing about 26 percent of world production. Sesame is the third important oilseed crop in India, next to groundnut and mustard. The major sesame growing states of India are Gujarat, Rajasthan, Uttar Pradesh, Andhra Pradesh, Orissa, Tamil Nadu, Madhya Pradesh, Maharashtra, Karnataka and West Bengal. The production and productivity of the crop varies from state to state and from year to year. Modern high yielding varieties represent the current pinnacle of achievement in adapting crop plants to present needs. However, we should remember that no variety is perfect. Today's best will not be good enough tomorrow. Genetic variation exists for agronomically vital characters in sesame but its production is still very low in India. Traditional sesame landraces as well as related wild species are an important source of genetic diversity for breeders.

The success of any crop improvement programme essentially depends on the nature and magnitude of variability present in the crop.

Genetic improvement of seed yield alone is not possible through phenotypic selection because of polygenic nature and low heritability. Hence resorting to selection through correlated response entailing several contributing factors which influence seed production both directly and indirectly shall be most appropriate. Therefore understanding of relationship between yield and its components is fundamental for selection process and its relationship can be explained by means of correlation and path coefficient analysis. Correlation studies enable breeders to know the strength of the relationship between various characters as well as direction of changes expected during selection. The path coefficient analysis provides a more realistic picture of the relationship as it considers direct as well as indirect effects of the variables by partitioning the correlation coefficients. In sesame, path analysis has used to identify traits that have significant effects on seed yield.

Materials and Methods

The experimental material used in the present investigation comprised of twenty seven genotypes of sesame which were obtained from All India Coordinated Research Project on Sesame & Niger (ICAR), JNKVV Campus, Jabalpur, Madhya Pradesh. They were selected on the basis of duration, suitable for Kharif season and yield. The field lay out was done in Randomized Block Design with 3 replications. Each entry was represented by a 08 row per plot of 2.4 m length with a Row-to-Row spacing of 30 cm and plant to plant spacing of 10 cm. The experiment was conducted in a well prepared field during *kharif* 2016-17 at Agriculture Farm, Nana Ji Deshmukh New Agriculture Campus, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (M.P.). Normal agronomic practices followed. Observations were recorded on Days to 50% flowering, Internode length, Number of capsules per plant, Capsule Length, Plant height (cm), Days to maturity, Plant stand per plot, Number of seeds per capsule, 1000-seed weight(g), Oil Content, Seed Yield per Plot(gm) and Seed yield (kg/ha). The analysis of variance for the design of the experiment was carried out according to the procedure outlined by Panse and Sukhatme (1967) [14]. The correlation coefficients and path analysis between different characters at genotypic and phenotypic levels was worked out between characters as suggested by Dewey and Lu (1959) [6].

Results and Discussion

The analysis of variance revealed highly significant differences among the genotypes in respect of all the traits (Table 1) thereby indicating presence of wide genetic variability. Character association studies revealed that the genotypic correlation coefficients were higher than phenotypic correlation coefficients indicating strong inherent association between the characters (Table 2a and Table 2b). The seed yield (kg/ha) exhibited highly significant and positive correlation with seed yield /plot and number of seeds per capsule while significant and negative correlation had exerted with plant height and internode length at both genotypic and phenotypic level. This is in consonance with the results of Singh, *et al.* (2000) [22], Begum and Dasgupta (2003) [4], Mothilal, *et al.* (2004) [12], Sengupta and Datta (2004) [18], Banerjee and Kole (2006) [3], Parameswarappa *et al.* (2009) [15], Yol, *et al.* (2010) [28], Teklu *et al.* (2014) [25], Abate and Mekbib (2015) [1], Mustafa, *et al*., (2015) [13], Fazal, *et al*. (2015) [7] and Majumdar, *et al.* (1987) [11] for no. of seeds per capsule and Ismaila and Usman (2012) [9] reported seed yield exhibited negatively significant with plant height and internode length.

Seed yield / plot exhibited highly significant and negative correlation with internode length, 1000-seed weight, days to 50% flowering and days to maturity exerted negative correlation at both genotypic and phenotypic level. Similar kind of observations were recorded by Yol *et al.* (2010) [28], Gidely *et al.* (2012), Teklu *et al.* (2014) [25], Abate and Mekbib (2015) [1], Sabiel *et al.* (2015) [17].

The character oil content showed significant and positive correlation with internode length, day to maturity and plant height at genotypic level while significant & positive correlation with internode length at phenotypic level. The results were in conformity with the findings of Teklu *et al.* (2014) [25] for internode length and plant height.

The 1000-seed weight showed highly significant and positive correlation with plant stand per plot, no. of capsules per plant, capsule length and days to maturity at genotypic level, where as highly significant and positive correlation with plant stand per plot and significant correlation with days to maturity at phenotypic level. These results were in accordance with the findings of Yol, *et al.* (2010) [28], Gidely *et al.* (2012), Ismaila and Usman (2012) [9], Fazal *et al.* (2015) [7] and Mustafa *et al.* (2015) [13].

No. of seeds per capsule exhibited highly significant and positive correlation with plant stand per plot at genotypic level whereas highly significant and positive correlation with plant stand per plot and no. of capsules per plant at phenotypic level. These results are in agreement with the findings of Yol, *et al*. (2010) [28], Gidely *et al*. (2012), Fazal *et al*. (2015) [7] and Mustafa *et al*. (2015) [13] for no. of capsules per plant.

Days to maturity exhibited highly significant and positive correlation with days to 50% flowering at both genotypic and phenotypic level. These results were in accordance with the findings by Teklu *et al*. (2014) [25].

The character plant height showed significant and positive correlation with internode length while highly significant at both genotypic and phenotypic level. Similar kind of observations were recorded by Teklu *et al.* (2014) [25].

Capsule length exhibited highly significant and positive correlation with no. of capsules/plant at both genotypic and phenotypic level. Similar kind of observations were recorded by Teklu *et al.* (2014) [25].

The association analysis revealed that seed yield /plot and number of seeds per capsule were the important characters and may be selected to increase the seed yield. Present findings also revealed that by making selection for a particular character, simultaneous improvement in the associated character may be achieved.

Among the characters studied, path coefficient analysis revealed that the positive direct effect on seed yield / plot was exhibited by No. of seeds / capsule followed by No. of capsules / plant, Oil content and 1000 seed weight at genotypic level (Table 3). The positive direct effect of one or more of these characters were in accordance with the findings by Solanki and Gupta (2000) [23], Sharma and Mandal (2001) [19], Babu *et al.* (2004) [2], Vidhyavathi *et al.* (2005) [26], Banerjee and Kole (2006) [3], Sudhakar *et al.* (2007) [24], Kumhar *et al*. (2008) [10], Parameswarappa *et al.* (2009) [15], Yol *et al*. (2010) [28], Renuka *et al*. (2011) [16], Chandra Mohan (2011) [5], Gidey *et al*., (2012) [8], Shekhawat *et al.*

(2013) [20], Teklu *et al.* (2014) [25], Fazal *et al*. (2015) [7] and Mustafa and Mahmood (2015) [13].

Therefore, these traits may be considered as the principal traits while selecting for seed yield. Selection indices may be formed by considering all these characters for improvement of seed yield.

Table 1: Analysis of Variance for 12 quantitative and qualitative characters in Sesame.

S. No.	Characters	Mean Sum of Square			CV %
		Replication	Treatments	Error	
	Degree of freedom	2	26	52	
1	Days to 50% flowering	5.2716	40.6648**	7.4639	5.25
2	Internode length cm	0.3738	4.4715**	0.1359	5.59
3	No. of Capsules/ Plant	1.9259	76.4957**	26.2208	8.9
4	Capsule length (cm)	0.0181	0.1242**	0.0128	4.98
5	Plant height (cm)	0.1446	117.5497**	32.3674	6.42
6	Days to maturity	3.8148	15.1624**	2.5199	1.78
7	Plant stand per plot	5.2438	60.9829**	15.3881	2.24
8	No. of seeds per capsules	1.1481	46.2650**	2.1353	7.02
9	1000 seed weight(g)	0.0015	0.0251**	0.0063	2.45
10	Oil Content (%)	2.152	38.9042**	1.1893	2.36
11	Seed Yield/ plot(g)	359.4197	372.109	218.8132	3.92
12	Seed Yield (kg/ ha.)	2490.4568	22779.7734**	3354.6748	10.26

*Significant at 5%
**Significant at 1

Table 2a: Estimates of Genotypic Correlations for 12 different quantitative and qualitative characters in Sesame.

S. No.	Characters	Days to 50% flow.	Internode length cm	No. of Capsules / Plant	Capsule length (cm)	Plant height (cm)	Days to maturity	Plant stand per plot	No. of seeds per capsules	1000 seed weight(g)	Oil Content (%)	Seed Yield/ plot(g)	Seed Yield (kg/ ha.)
1	Days to 50% flowering	1.000	0.204	0.097	0.094	-0.073	0.927	-0.032	0.093	0.102	0.132	-0.447	-0.057
2	Internode length cm	0.204	1.000	-0.034	0.036	0.397	-0.026	-0.011	-0.005	0.069	0.265	-0.868	-0.353
3	No. of Capsules/ Plant	0.097	-0.034	1.000	0.445	-0.214	0.117	0.762	0.294	0.500	0.127	-0.182	0.104
4	Capsule length (cm)	0.094	0.036	0.445	1.000	-0.520	0.202	0.013	0.239	0.336	0.057	-0.047	-0.151
5	Plant height	-0.073	0.397	-0.214	-0.520	1.000	-0.055	-0.284	0.007	-0.353	0.249	-0.162	-0.407
6	Days to maturity	0.927	-0.026	0.117	0.202	-0.055	1.000	0.013	0.001	0.312	0.222	-0.416	-0.053
7	Plant stand per plot	-0.032	-0.011	0.762	0.013	-0.284	0.013	1.000	0.554	0.713	0.011	-0.051	0.000
8	No. of seeds per capsules	0.093	-0.005	0.294	0.239	0.007	0.001	0.554	1.000	0.130	-0.075	0.089	0.438
9	1000 seed weight(g)	0.102	0.069	0.500	0.336	-0.353	0.312	0.713	0.130	1.000	0.019	-0.465	-0.249
10	Oil Content (%)	0.132	0.265	0.127	0.057	0.249	0.222	0.011	-0.075	0.019	1.000	-0.216	-0.082
11	Seed Yield/ plot(g)	-0.447	-0.868	-0.182	-0.047	-0.162	-0.416	-0.051	0.089	-0.465	-0.216	1.000	0.179
12	Seed Yield (kg/ ha.)	-0.057	-0.353	0.104	-0.151	-0.407	-0.053	0.000	0.438	-0.249	-0.082	0.179	1.000

Table 2b: Estimates of Phenotypic Correlations for 12 different quantitative and qualitative characters in Sesame.

S. No.	Character	Days to 50% Flowering	Internode Length (cm)	No. of Capsules / Plant	Capsule Length (cm)		Plant Height (cm)		Days to Maturity		Plant Stand Per Plot		No. of Seeds Per Capsules		1000 Seed Weight (g)		Oil Content (%)		Seed Yield / Plot(g)		Seed Yield (kg / ha.)	
1	Days to 50% Flow.	1.000	0.148	0.155	0.064		0.082		0.672	**	-0.087		0.047		0.054		0.122		-0.043		-0.030	
2	Internode Length (cm)	0.148	1.000	0.029	0.030		0.283	*	0.003		0.028		0.000		0.042		0.254	*	-0.292	**	-0.244	*
3	No. of Capsules / Plant	0.155	0.029	1.000	0.330	**	-0.107		0.086		0.386	**	0.224	*	0.182		0.108		0.136		0.035	
4	Capsule Length (cm)	0.064	0.030	0.330	1.000		-0.341	**	0.120		0.072		0.205		0.157		0.043		0.039		-0.033	
5	Plant Height (cm)	0.082	0.283	-0.107	-0.341		1.000		0.056		-0.142		-0.034		-0.080		0.177		-0.069		-0.261	*
6	Days to Maturity	0.672	0.003	0.086	0.120		0.056		1.000		-0.086		-0.014		0.201		0.166		0.025		-0.083	
7	Plant Stand Per Plot	-0.087	0.028	0.386	0.072		-0.142		-0.086		1.000		0.334	**	0.328	**	0.055		0.065		0.087	
8	No. of Seeds /Capsules	0.047	0.000	0.224	0.205		-0.034		-0.014		0.334		1.000		0.121		-0.081		0.054		0.313	**
9	1000 Seed Weight(g)	0.054	0.042	0.182	0.157		-0.080		0.201		0.328		0.121		1.000		-0.035		-0.025		-0.160	
10	Oil Content (%)	0.122	0.254	0.108	0.043		0.177		0.166		0.055		-0.081		-0.035		1.000		-0.110		-0.064	
11	Seed Yield / Plot(g)	-0.043	-0.292	0.136	0.039		-0.069		0.025		0.065		0.054		-0.025		-0.110		1.000		0.350	**
12	Seed Yield (kg / ha.)	-0.030	-0.244	0.035	-0.033		-0.261		-0.083		0.087		0.313		-0.160		-0.064		0.350		1.000	

Table 3: Direct and indirect effects for different characters on Seed Yield/ plot (g) at genotypic level in Sesame.

S. No.	Character	Days to 50% Flowering	Internode Length (cm)	No. of Capsules / Plant	Capsule Length (cm)	Plant Height (cm)	Days to Maturity	Plant Stand Per Plot	No. of Seeds Per Capsules	1000 Seed Weight (g)	Oil Content (%)
1	Days to 50% Flowering	-0.220	-0.045	-0.021	-0.021	0.016	-0.204	0.007	-0.020	-0.023	-0.029
2	Inter node Length (cm)	-0.141	-0.693	0.024	-0.025	-0.275	0.018	0.008	0.003	-0.048	-0.183
3	No. of Capsules / Plant	0.051	-0.018	0.524	0.233	-0.112	0.061	0.399	0.154	0.262	0.066
4	Capsule Length (cm)	-0.055	-0.021	-0.261	-0.588	0.306	-0.119	-0.008	-0.140	-0.197	-0.033
5	Plant Height (cm)	0.030	-0.163	0.088	0.213	-0.409	0.023	0.116	-0.003	0.145	-0.102
6	Days to Maturity	-0.241	0.007	-0.030	-0.053	0.014	-0.260	-0.003	0.000	-0.081	-0.058
7	Plant Stand Per Plot	0.033	0.012	-0.779	-0.014	0.290	-0.013	-1.022	-0.566	-0.729	-0.011
8	No. of Seeds Per Capsules	0.061	-0.003	0.194	0.158	0.005	0.001	0.366	0.661	0.086	-0.049
9	1000 Seed Weight(g)	0.012	0.008	0.059	0.039	-0.041	0.037	0.084	0.015	0.117	0.002
10	Oil Content (%)	0.024	0.048	0.023	0.010	0.045	0.040	0.002	-0.013	0.003	0.181
11	Seed Yield / Plot(g)	-0.447	-0.868	-0.182	-0.047	-0.162	-0.416	-0.051	0.089	-0.465	-0.216
	Partial R^2	0.098	0.602	-0.095	0.027	0.066	0.108	0.052	0.059	-0.054	-0.039
R SQUARE = 0.8234 RESIDUAL EFFECT = 0.4203						Direct Effect on main Diagonal (Bold figure)					

Acknowledgements

The authors are greatfully thanks to Project Coordinator (Sesame and Niger), AICRP on Sesame and Niger, JNKVV, Jabalapur (MP) for having supplied 27 Sesame germplasm collections for the study.

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