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Genetic Variability and Character Association in Sesame (*Sesamum indicum* L.) Genotypes

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A B S T R A C T

The study was carried out to assess the genetic variability and association of traits with respect to seed yield and its components in sesame genotypes. Seventy five sesame genotypes were grown during *kharif* 2016 at the Project Coordinating Unit Sesame and Niger, JNKVV, Jabalpur for the estimation of phenotypic and genotypic variances, heritability, genetic advances, correlation and path coefficient analysis for seed yield and yield related traits. High values for phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was recorded for traits *viz*., number of secondary branches/plant followed by number of primary branches/plant, seed yield/plant, number of seeds/capsule, number of capsules/plant, transpiration rate, stomatal conductance, photosynthetic rate, chlorophyll content and days to flower initiation and hence improvement through selection of these traits could be possible. High heritability coupled with moderate genetic advance was recorded for oil content and days to 50% flowering. Thus, these traits are most likely controlled by additive gene action which is very useful in selection. Correlation and path analysis revealed that the characters *viz*., plant height, number of secondary branches/plant, number of seeds/capsule and oil content have positive direct association along with significant positive correlation with seed yield. Therefore, these characters can be considered as a criterion for improving seed yield in breeding programs of sesame.

Introduction

Sesame (*Sesamum indicum* L.) known as 'benni seed', 'gingelly', 'simsim', 'til' etc., is an important and perhaps the oldest and ancient oilseed crops known to man. It is cultivated extensively from tropical regions to the temperate zones in the world. It is fifth important edible oil crop in India after groundnut, rapeseed-mustard, sunflower and soybean. Sesame seed contains 50% oil, 23% protein and 15% carbohydrate (Ranganatha *et al*., 2012). Sesame seed oil has long shelf life due to the presence of lignans (sesamin, sesamol, sesamolin), which have remarkable antioxidant function, resisting oxidation. It can set seed and yield well under fairly high temperature and can grow in stored soil moisture without rainfall and irrigation. However, continuous flooding or severe drought adversely affects the crop resulting in low yield.

Genetic variation survives 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 and form the backbone of agricultural production. Selection for high yielding types with wider adaptability shall help in increasing the production both locally and globally. But the performance of crop is affected by such factors as climatic, nutrients, water availability, inter and intra specific competitions, pest and diseases, as well as socio-cultural and socioeconomic factors. The knowledge of genetic variability in germplasm will help in the selection and breeding of high yielding, good quality cultivars that will increase production. It is necessary to study variability in respect of quantitative characters with reference to genetic parameters such as genotypic and, phenotypic variances, heritability (broad sense) and genetic advance.

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 analysis is used to understand the relationships existing between yield and yield components. However, correlation alone does not provide the exact knowledge and contribution made by the yield attributes. Path coefficient analysis has been suggested to separate correlation coefficient into direct and indirect effects. In sesame, path analysis has used to identify traits that have significant effects on seed yield

Materials and Methods

The present experiment was conducted under Project Coordinating Unit (Sesame and Niger) Research Farm, JNKVV, Jabalpur (M.P.) during *kharif* 2016. The soil of the experimental area is medium black with uniform topography and free from water logged conditions. Jabalpur has sub-tropical and semi-arid climate. The main features are hot and dry summer and cold winter with occasional showers. The experimental material consisted of 75 sesame genotypes laid out in a Randomized Block Design replicated thrice. The distance between rows was maintained at 0.30 m and plant to plant 0.10 m. The crop was raised under recommended package of practices along with prophylactic protection measures. The observations were recorded on days to flower initiation, days to 50% flowering, plant height (cm), number of primary branches/plant, number of secondary branches/plant, number of capsules/plant, capsule length(cm), days to maturity, number of seeds/capsule, 1000 seed weight (g), seed yield/plant (g) and oil content (%). The data were subjected to statistical analysis

Statistical analysis

Mean values of the characters for each genotype per replication were used for analysis of variance as per (Cochran and Cox, 1950). Heritability estimates were calculated according to (Hanson, 1956) and genetic advance according to (Johnson, 1955). Genotypic and phenotypic correlation coefficients were calculated according to the formula suggested by (Miller *et al.*, 1958). Path coefficients were estimated by following (Dewey and Lu, 1959). The estimates of correlation coefficient and path coefficient analysis were calculated by analyzing data using INDOSTAT statistical package.

Results and Discussion

The analysis of variance revealed significant difference among the genotypes for all traits *viz*., days to flower initiation, days to 50% flowering, plant height, number of primary branches/plant, number of secondary branches/plant, number of capsules/plant,

capsule length, days to maturity, number of seeds/capsule, 1000 seed weight, oil content (%), leaf area index, photosynthetic rate, chlorophyll content, stomatal conductance, transpiration rate, water use efficiency and seed yield/plant, indicating the presence of sufficient variability among the evaluated genotype for the traits under consideration. This indicates that sufficient variability is present for most of the important characters among different genotypes. Similar results have been reported by Shekhawat *et al.*, (2013) for days to flowering, plant height, capsule bearing length, capsules/plant, capsule length, seed yield/plant, days to maturity and oil content; Sabiel *et al.*, (2015) for plant height, flowering time and days to maturity.

Examination of the components of variance revealed that the phenotypic coefficients of variation (PCV) was higher than the corresponding genotypic coefficients of variation (GCV) for all the characters with a narrow difference indicates that environmental influence was least and preponderance of genetic factors controlling variability in these traits. High magnitude of PCV and GCV were observed for the traits *viz*., number of secondary branches/plant followed by number of primary branches/plant, seed yield/plant, number of seeds/capsule, number of capsules/plant, transpiration rate, stomatal conductance, photosynthetic rate, chlorophyll content and days to flower initiation. Results indicated greater scope for selection of these traits for further breeding work. Similar results have been reported by Sekhawat *et al.*, (2013), Gangadhara *et al.*, (2012) and Parameshwarappa *et al.*, (2009) for seed yield/plant; Aristya *et al.*, (2017), Saxena *et al.*, (2016), Desawi *et al.*, (2014) for number of capsules/plant; Mustafa *et al.*, (2015), Rani (2014) for number of primary branches/plant and number of secondary branches/plant; Narayan and Murugan (2013) for number of seeds/capsule. Moderate values of PCV were noticed for characters *viz*., days to 50% flowering, plant height, water use efficiency and oil content (%). Similar results have been recorded by Vanishree *et al.*, (2013) and Gidey *et al.*, (2013) for days to 50% flowering. Low values of PCV were noticed for capsule length, 1000 seed weight and days to maturity. Similar results have been reported by Sekhawat *et al.*, (2013) and Vanishree *et al.*, (2013), respectively.

However, high GCV value alone is not sufficient for the determination of the extent of genetic advance to be expected by selection. Burton (1952) suggested that GCV together with heritability estimates would give the best picture of the extent of the advance to be expected by selection.

The highest value of heritability was noted in chlorophyll content followed by leaf area index, days to flower initiation, numbers of capsules/plant. Hence these traits might be governed by additive genes indicating that direct selection would be effective from present genotypes. Similar results have been reported by Vanishree *et al.*, (2013), Shekhawat *et al.*, (2013), Kumhar *et al.*, (2013), Gangadhara *et al.*, (2012) for number of capsules/plant.

Heritability estimates would be reliable if accompanied by a high estimated genetic advance. High heritability coupled with moderate genetic advance was recorded for oil content and days to 50% flowering. THus these traits are most likely controlled by additive gene action which is very useful in selection. Similar results were reported by Gangadhara *et al.*, (2012), Gidey *et al.*, (2012), Tripathi *et al.*, (2013) and Abate and Mekbib (2015) for days to 50% flowering. Moderate heritability coupled with high genetic advance was recorded for stomatal conductance, number of primary branches/plant and seed yield/ plant (Table 1–4).

Table.1 Analysis of variance for yield and yield related traits in sesame

S. No.	Source of Variation	d. f.	Days to flower initiation	Days to 50% flowering	Plant height	Number of primary branches/plant	Number of secondary branches/ plant	Number of capsules plant	Capsule length	Maturity days	Number of seed/ capsule	1000 seed wt.	Oil content (%)	LAI	Photo-synthetic rate	Chlorophyll content	Stomatal conductance	Transpiration rate	WUE	Seed yield/ plant
1	**Replications**	2	3.05	5.63	27.50	13.18	30.72	94.62	0.0036	54.08	386.35	0.0124	0.0037	0.108	10.76	116.68	0.000152	0.506	0.039	18.12
2	**Treatments**	74	48.76**	48.31**	167.5**	2.11**	1.67**	104.24**	0.026**	17.68**	121.84**	0.0496**	27.24**	0.783**	8.22**	82.44**	0.0040**	0.6196**	0.249**	8.35**
3	**Error**	148	1.62	2.58	34.99	0.40	0.42	9.03	0.013	6.91	67.54	0.0189	1.13	0.041	1.08	1.65	0.000506	0.085	0.078	1.95
4	**SEm ±**	-	0.73	0.92	3.41	0.36	0.37	1.73	0.068	1.51	4.74	0.079	0.6161	0.1176	0.6026	0.7417	0.013	0.1688	0.1613	0.8083
5 a	**CD 5%**	-	2.05	2.59	9.54	1.03	1.05	4.84	0.190	4.24	13.26	0.223	1.72	0.3288	1.68	2.07	0.0363	0.4717	0.4507	2.25
5 b	**CD 1%**	-	2.71	3.43	12.60	1.36	1.39	6.40	0.251	5.60	17.51	0.293	2.27	0.4341	2.23	2.73	0.048	0.6228	0.5951	2.98

*Significant at 5%
**Significant at 1

Table.2 Parameters of genetic variability for yield and yield related traits in sesame genotype

S. No.	Character	Mean	Range		CV%	PCV (%)	GCV (%)	Heritability h^2b (%)	GA as % of mean5%
			Min.	Max.					
1	Days to flower initiation	34.05	29.00	41.33	3.73	12.22	11.63	90.60	22.82
2	Days to 50% flowering	38.96	34.00	48.00	4.12	10.83	10.02	85.50	19.08
3	Plant height(cm)	82.77	63.55	100.11	7.14	10.73	8.01	55.70	12.32
4	Number of primary branches/plant	4.08	2.83	6.50	15.62	24.17	18.45	58.20	29.00
5	Number of secondary branches/plant	3.51	2.00	5.00	18.63	26.12	18.32	49.20	26.46
6	Number of capsules/plant	41.92	29.00	57.00	7.16	15.22	13.43	77.80	24.42
7	Capsule length(cm)	2.59	2.34	2.83	4.55	5.16	2.44	22.40	2.38
8	Days to maturity	89.80	86.00	96.00	2.92	3.60	2.11	34.20	2.54
9	Number of seeds/capsule	57.08	33.00	75.66	14.39	16.21	7.45	21.10	7.05
10	1000 seed weight(g)	3.57	3.19	3.76	3.85	4.77	2.82	35.00	3.44
11	Oil content (%)	44.59	34.00	52.10	2.39	7.03	6.61	88.40	12.81
12	Leaf area index	3.87	2.66	5.10	5.26	13.88	12.85	85.60	24.50
13	Photosynthetic rate(µmol/m^2/s)	13.32	9.18	16.33	7.82	13.96	11.56	68.60	19.72
14	Chlorophyll content	43.43	32.08	53.49	3.02	12.59	12.22	94.20	24.45
15	Stomatal conductance(mmol/m^2/s)	.29.00	0.22	0.39	7.73	14.10	11.79	69.90	20.31
16	Transpiration rate(mmol/m^2/s)	3.59	2.79	4.66	8.13	14.29	11.74	67.60	19.89
17	Water use efficiency(µmol/mol)	3.72	2.82	4.26	7.49	9.86	6.42	42.30	8.60
18	Seed yield/ plant(g)	9.30	6.59	15.63	15.04	21.74	15.69	52.10	23.33

Classes of Heritability (%): High >70 %, Medium 50-70%, Low < 50 %
Classes of Genetic Advance (%): High >20%, Medium 10-20%, Low < 10 %

Table.3 Phenotypic and Genotypic correlation analysis for yield and yield related traits in sesame genotypes

Character		Days to flower-initiation	Days to 50% flowering	Plant height	Number of primary branches/ plant	Number of secondary branches/plant	Number of capsules/plant	Capsule length	Days to maturity	Number of seeds /capsule	1000 seed weight	Oil content	Seed yield/plant
Days to flower initiation	**P**	**1.0000**	0.9786**	-0.0928	0.0706	-0.1032	-0.0566	0.0350	0.6565**	-0.0455	0.1217	0.0312	-0.2406**
	G	**1.0000**	0.9932	-0.1123	0.0620	-0.1660	-0.0691	0.0185	1.0363	-0.0640	0.2059	0.0150	-0.3596
Days to 50% flowering	**P**		**1.0000**	-0.1111	0.0579	-0.1234	-0.0733	0.0535	0.6837**	-0.0366	0.1462*	0.0237	-0.2387**
	G		**1.0000**	-0.1241	0.0471	-0.2068	-0.0848	0.0265	1.0513	-0.0438	0.1961	0.0045	-0.3707
Plant height	**P**			**1.0000**	-0.352	0.0677	0.4025**	0.1695*	-0.081	0.0496	0.0298	-0.0143	0.2159**
	G			**1.0000**	-0.0348	0.1011	0.4943	0.2522	-0.1686	0.3029	0.0838	0.0453	0.4758
Number of primary branches/ plant	**P**				**1.0000**	0.4082**	0.0391	0.0564	0.0244	0.0174	-0.0993	0.1207	-0.0723
	G				**1.0000**	0.4492	0.0296	0.1002	0.1613	-0.0009	-0.2006	0.1307	-0.1780
Number of secondary branches/ plant	**P**					**1.0000**	0.1194	-0.1429*	-0.0508	0.1595*	-0.1068	0.2374**	0.1558*
	G					**1.0000**	0.1420	-0.2887	-0.0608	0.2895	-0.2293	0.3483	0.2056
Number of capsules/ plant	**P**						**1.0000**	0.0645	-0.0663	0.1072	0.1958**	0.1036	0.2701**
	G						**1.0000**	0.2549	-0.1646	0.2460	0.3138	0.1255	0.2898
Capsule length	**P**							**1.0000**	0.0634	-0.1183	0.0760	-0.0512	0.1212
	G							**1.0000**	-0.0150	-0.242	0.2809	-0.1027	0.4936
Days to maturity	**P**								**1.0000**	0.0381	0.1809**	0.0322	-0.1721**
	G								**1.0000**	-0.1245	0.1268	0.0346	-0.3746
Number of seeds/capsule	**P**									**1.0000**	-0.0574	0.1663*	0.2748**
	G									**1.0000**	-0.2846	0.3558	0.3192
1000 seed weight	**P**										**1.0000**	0.0664	-0.0258
	G										**1.0000**	0.0800	-0.1031
Oil content %	**P**											**1.0000**	0.2655**
	G											**1.0000**	0.3651

Significant label 0.05 0.01
If correlation r = 0.1308 0.1714

Table.4 Genotypic and Phenotypic path coefficient analysis showing direct and indirect effects for yield and yield related traits in sesame genotypes

Character		Days to flower initiation	Days to 50% flowering	Plant height	Number of primary branches/ plant	Number. of secondary branches/ plant	Number of capsules/ plant	Capsule length	Days to maturity	Number of seeds /capsule	1000 seed weight	Oil content (%)	Seed yield/ plant
Days to flower initiation	P	**-0.2206**	-0.2159	0.0205	-0.0156	0.0228	0.0125	-0.0077	-0.1448	0.0100	-0.0268	-0.0069	-0.2406
	G	**0.4507**	0.4476	-0.0506	0.0280	-0.0748	-0.0311	0.0083	0.4670	-0.0288	0.0928	0.0068	-0.3596
Days to 50% flowering	P	0.0605	**0.0619**	-0.0069	0.0036	-0.0076	-0.0045	0.0033	0.0423	-0.0023	0.0090	0.0015	-0.2387
	G	-0.4112	**-0.4140**	0.0514	-0.0195	0.0856	0.0351	-0.0110	-0.4352	0.0181	-0.0812	-0.0019	-0.3707
Plant height	P	-0.0076	-0.0091	**0.0817**	-0.0029	0.0055	0.0329	0.0138	-0.0066	0.0041	0.0024	-0.0012	0.2159
	G	-0.0210	-0.0232	**0.1872**	-0.0065	0.0189	0.0926	0.0472	-0.0316	0.0567	0.0157	0.0085	0.4758
Number of primary branches/plant	P	-0.0107	-0.0087	0.0053	**-0.1510**	-0.0616	-0.0059	-0.0085	-0.0037	-0.0026	0.0150	-0.0182	-0.0723
	G	-0.0312	-0.0237	0.0175	**-0.5032**	-0.2260	-0.0149	-0.0504	-0.0812	0.0004	0.1009	-0.0658	-0.1780
Number of secondary branches/plant	P	-0.0107	-0.0128	0.0070	0.0424	**0.1040**	0.0124	-0.0149	-0.0053	0.0166	-0.0111	0.0247	0.1558
	G	-0.0649	-0.0809	0.0395	0.1756	**0.3910**	0.0555	-0.1129	-0.0238	0.1132	-0.0897	0.1362	0.2056
Number of capsules/plant	P	-0.0097	-0.0126	0.0693	0.0067	0.0206	**0.1721**	0.0111	-0.0114	0.0185	0.0337	0.0178	0.2701
	G	0.0042	0.0051	-0.030	-0.0018	-0.0086	**-0.0607**	-0.0155	0.0100	-0.0149	-0.0190	-0.0076	0.2898
Capsule length	P	0.0059	0.0090	0.0286	0.0095	-0.0241	0.0109	**0.1685**	0.0107	-0.0199	0.0128	-0.0086	0.1212
	G	0.0144	0.0206	0.1957	0.0778	-0.2241	0.1978	**0.7761**	-0.0117	-0.1878	0.2180	-0.0797	0.4936
Days to maturity	P	-0.0388	-0.0404	0.0048	-0.0014	0.0030	0.0039	-0.0037	**-0.0591**	-0.0023	-0.0107	-0.0019	-0.1721
	G	-0.2351	-0.2385	0.0383	-0.0366	0.0138	0.0373	0.0034	**-0.2269**	0.0282	-0.0288	-0.0079	-0.3746
Number of seeds/capsule	P	-0.0096	-0.0078	0.0105	0.0037	0.0338	0.0227	-0.0251	0.0081	**0.2121**	-0.0122	0.0353	0.2748
	G	-0.0076	-0.0052	0.0361	-0.0001	0.0345	0.0293	-0.0289	-0.0148	**0.1193**	-0.0339	0.0424	0.3192
1000 seed weight	P	-0.0065	-0.0078	-0.0016	0.0053	0.0057	-0.0104	-0.0040	-0.0096	0.0030	**-0.0530**	-0.0035	-0.0258
	G	-0.0631	-0.0601	-0.0257	0.0615	0.0703	-0.0962	-0.0861	-0.4389	0.0872	**-0.3066**	-0.0245	-0.1031
Oil content (%)	P	0.0071	0.0054	-0.0032	0.0274	0.0538	0.0235	-0.0116	0.0073	0.0377	0.0151	**0.2266**	0.2665
	G	0.0054	0.0016	0.0163	0.0469	0.1249	0.0450	-0.0368	0.0124	0.1276	0.0287	**0.3586**	0.3651

R Square = 0.9016
Residual effect = 0.3137
Note: Diagonal bold figure are the directs effect and the off diagonal are Indirect effects.

Moderate heritability coupled with moderate genetic advance was recorded for transpiration rate, plant height and photosynthetic rate. Similar results have been reported by Tripathi *et al.,* (2013) for plant height; Low heritability coupled with high genetic advance was recorded for number secondary branches/plant. Low heritability coupled with low genetic advance was recorded for 1000 seed weight, days to maturity, capsule length, number of seeds/capsule and water use efficiency. Similar results have been reported by Shekhawat *et al.,* (2013) for 1000 seed weight and capsule length; Abate and Mekbib (2015) for days to maturity and number of seeds/capsule.

Phenotypic correlation coefficient was estimated in all character combinations with the objective to get information about the nature, extent and direction of selection pressure to achieve practical and usable results. In general, genotypic correlation coefficients were higher in magnitude than the phenotypic correlation coefficient. This indicated that although there is strong inherent association between the various pairs of characters studied the low phenotypic correlation would result from the masking and modifying effects of environment on the association of characters at gene level. Shekhawat *et al.,* (2013) also reported that genotypic correlation coefficients were higher than the respective phenotypic correlation coefficients for all the characters.

Study revealed that seed yield/plant showed highly positive significant correlation with number of seeds/capsule followed by number of capsules /plant, oil content, plant height and number of secondary branches/plant. Similar results were reported by Fazal *et al.,* (2015), Bharathi *et al.,* (2015), Abate and Mekbib (2015) for number of seeds/capsule; Bharathi *et al.,* (2015), Fazal *et al.,* (2015), Ismaila and Usman (2014) for number of capsules/plant. The association analysis revealed that plant height, number of primary branches/ plant, number of capsules/plant and 1000 seed weight 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.

Path coefficient analysis was carried out using genotypic and phenotypic correlation coefficients and revealed that substantial positive direct effect on seed yield was exerted by capsule length, days to flower initiation, number of secondary branches/plant, oil content, plant height and number of seeds/ capsule. 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. Similar results have been reported by Vanishree *et al.,* (2013) for capsule length; Abate and Mekbib (2015) and Shekhawat *et al.,* (2013) for plant height; Saxena and Bisen (2016) for number of branches/plant; Fazal *et al.,* (2015) and Bharathi *et al.,* (2015) for number of seeds/capsule.

Thus, on the basis of above study the characters *viz.,* plant height, number of secondary branches/plant, number of seeds/capsule and oil content have positive direct association along with significant positive correlation with seed yield. Therefore, these characters can be considered as a criterion for improving seed yield in breeding programs of sesame.

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