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

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Abstract
The present investigation was conducted with twenty-one genotypes following RBD with three replications during *kharif*, 2017. Data on morpho-physiological and yield traits were recorded on six randomly selected plants. The analysis of variance revealed significant differences among the genotypes for each character, indicating the presence of considerable variability among the genotypes for the characters studied. Correlation studies indicated that harvest index, productive capsules per plant, number of seeds per capsule, number of branches per plant, productive branches per plant, biological yield, 1000 seed weight and plant height showed significant positive association with seed yield per plant as well as among themselves at phenotypic and genotypic level. Hence, selection for any one of these characters would bring in simultaneous improvement of other character and ultimately seed yield. The traits *viz.*, plant height, number of branches per plant, days to maturity, number of seeds per capsule, biological yield and harvest index had positive direct effect on seed yield. Path analysis revealed that high positive direct effect was exhibited by number of branches per plant, biological yield and harvest index with positive and significant correlation for seed yield; hence, selection based on these characters would be more effective for yield improvement in sesame.

Keywords: Sesame, Variance, Correlation, Direct effect, Path analysis, Seed yield

Introduction
Sesame (*Sesamum indicum* L.,) is very ancient oilseed crop grown next to groundnut, rapeseed and mustard in India. The knowledge of nature and extent of genetic variation available in the germplasm or breeding material helps the breeder for planning sound breeding programme. Hence, the present investigation was undertaken to evaluate twenty-one sesame genotypes for yield and yield traits. The correlation coefficient analysis was measured for the mutual relationship between two component characters and for determining the component characters on which selection can be based for genetic improvement of the yield. The correlation coefficient between yield and a particular yield component was the net result of direct effect of that attribute and indirect effect through other yield contributing traits. The total correlation between yield and a component trait may sometimes be misleading as it might be an over-estimate or under-estimate.

Materials and Method
The field experiment was conducted during Kharif 2017 at TCA, Dholi. Twenty-one genotypes of sesame with observation of eleven yield and yield contributing traits were taken in order to reveal the amount of variability, correlation between yield and its contributing traits along with path analysis for seed yield through direct and indirect effects in the experimental material. The analysis of variance (ANOVA) was worked out as per methodology advocated by Panse and Sukhatme (1967) [5]. Correlation coefficient analysis measures the mutual relationship between two component characters and determines the component characters on which selection can be based for genetic improvement of the yield as suggested by Johnson *et*

al., 1955 [4]. To partition the total correlation coefficients into direct and indirect effects of cause used in present study was devised by Dewey and Lu (1959) [3].

Results and Discussion

The analysis of variance (Table 1) showed highly significant differences among the genotypes for all the eleven traits under study indicating the presence of considerable genetic variability among the experimental material which provides ample scope for selecting superior genotypes by the plant breeder for further improvement.

In order to find out the degree and direction of relationship of the yield contributing characters with yield and inter relationship among themselves, correlation coefficient analysis (phenotypic and genotypic) was carried out for all the traits under investigation. Correlation analysis showed that phenotypic and genotypic correlation for most of the character pairs were in same direction and genotypic estimates were higher than the phenotypic one, indicating inherent association between the characters (Table 2 & 3). Seed yield per plant showed positive and significant correlation with number of branches per plant (0.54**), productive branches per plant (0.49*), productive capsules per plant (0.60**), number of seeds per capsule (0.57*), 1000 seed weight (0.46*), biological yield (0.53**) and harvest index (0.89**) exhibited highly significant and positive association with seed yield. Hence selection for any one at these characters would bring in simultaneous improvement of other character and also finally improvement in seed yield. However, negative and significant correlation of seed yield per plant was recorded with days to maturity (-0.47*), whereas it showed negative but non-significant association with days to 50 per cent flowering (-0.30). Similar results were observed by many researchers including Bhuvan & Sharma (2004) [2] for number of branches per plant and number of capsules per plant, Sankar and Kumar (2003) [7] for number of seeds per capsule and 1000 seed weight, Pawar *et al*. (2002) [6] for biological yield and harvest index. On contrary, negative significant association between seed yield and days to maturity and non-significant negative association with days to 50 per cent flowering. The results indicated that seed yield was increased whenever there was increase in characters that were positive and significantly associated with seed yield. These characters can be considered as criteria for selection for higher yield as these were mutually and directly associated with seed yield.

The path analysis reveals whether the association of characters with yield is due to their direct effect on yield or is a consequence of their indirect effects via other component characters. In other words, it measures the cause of association between two variables. The direct and indirect effects of different component characters with grain yield at genotypic and phenotypic level were tabulated in Table 4 and 5 respectively. The path coefficient analysis was performed for seed yield per plant taking it as a dependent variable and ten other characters as independent variables. Both phenotypic and genotypic paths were worked out but genotypic path was considered with a greater weightage as the phenotypic path may have a greater influence of environmental factors. Days to 50 per cent flowering had negative moderate direct effect on seed yield. However, it exhibited indirect negative effect on seed yield *via* plant height, number of branches per plant, number of seeds per capsule, biological yield and harvest index. Whereas, it showed positive indirect effect through days to maturity, productive branches per plant, productive capsules per plant and 1000 seed weight. Since this trait showing high correlation and direct effect on seed yield per plant, one can improve the seed yield per plant by making selection for this character during yield improvement programme. Similar results were found by many researchers including Bharathi *et al*., (2015) [1]. Low and positive direct effect of plant height was observed on seed yield whereas, positive and indirect effect on seed yield observed *via* days to 50 per cent flowering, number of branches per plant, biological yield and harvest index but negative indirect effect was reported *via* Days to maturity, productive branches per plant, productive capsules per plant and 1000 seed weight. Number of branches exhibited very high and positive direct effect on seed yield whereas, positive indirect effect on seed yield of number of branches observed *via* days to 50 per cent flowering, plant height, number of seeds per capsule, biological yield and harvest index, negative and indirect effect was observed *via* productive branches per plant followed by days to maturity, productive capsules per plant and 1000 seed weight. Days to maturity had moderate positive direct effect on seed yield. Whereas, it showed positive indirect effect *via* productive branches per plant, productive capsules per plant and 1000 seed weight. However, it exhibited negative indirect effect through days to 50 per cent flowering, plant height, number of branches per plant, number of seeds per capsule, biological yield and harvest index. Direct effect of productive branches per plant was found to be high negative direct effect on seed yield. Whereas, it showed positive indirect effect on seed yield per plant *via* days to 50 per cent flowering, plant height, number of branches per plant number of seeds per capsule, biological yield and harvest index but through days to maturity, productive capsule per plant and 1000 seed weight had negative direct effect on seed yield. Productive capsules per plant had found negative and negligible direct effect on seed yield and through days to maturity, productive branches per plant, 1000 seed weight, it exhibited negative indirect effect on seed yield. Whereas, *via* days to 50 per cent flowering, plant height, number of branches per plant, number of seeds per capsule, biological yield and harvest index, it showed positive indirect effect on seed yield. The direct effect of number of seed per capsule was reported low positive on seed yield, whereas *via* number of branches per plant, it showed very high positive indirect effect on seed yield followed by harvest index, biological yield, plant height and days to 50 per cent flowering, whereas through productive branches per plant it reported high negative indirect effect on seed yield followed by days to maturity, productive capsules per plant and 1000 seed weight. 1000 seed weight had negligible negative direct effect on seed yield. Whereas, *via* days to maturity and productive capsules per plant, through days to 50 per cent flowering, plant height, number of branches per plant, number of seeds per capsule, biological yield and harvest index, it exhibited positive indirect effect on seed yield. Biological yield (dry matter per plant) showed positive and high direct effect on seed yield. However, *via* harvest index, days to 50 per cent flowering, number of branches per plant, plant height and number of seeds per capsule, it exhibited positive indirect effect on seed yield. Negative and negligible indirect effect of biological yield was observed *via* days to maturity, productive branches per plant, productive capsules per plant and 1000 seed weight. Harvest index exhibited high positive direct effect on seed yield, whereas through another traits *viz.* days to 50 per cent flowering, plant height, number of branches per plant, number of seeds per capsule and biological yield it exhibited positive

indirect effect on seed yield. However, *via* days to maturity, productive capsules per plant and 1000 seed weight, it showed negative indirect effect on seed yield. The direct effect of traits *viz.*, plant height, number of branches per plant, days to maturity, number of seeds per capsule, biological yield and harvest index had positive direct effect on seed yield whereas days to 50 per cent flowering, productive branches per plant, productive capsules per plant and 1000 seed weight had negative direct effect on seed yield. Path analysis revealed that high positive direct effect was exhibited by number of branches per plant, biological yield and harvest index. Hence, selection based on these characters would be more effective for yield improvement.

Table 1: Analysis of variance for eleven characters in sesame

Sl. No.	Characters	Mean sum of squares		
		Replication	Treatments	Error
1	Days to 50% flowering	4.333	49.171**	1.383
2	Plant height (cm)	62.613	3384.3401**	111.703
3	Number of branches p*er* plant	0.084	3.735**	0.359
4	Days to maturity	1.063	150.744**	2.747
5	Productive branches/plant	0.057	3.073**	0.283
6	Productive capsule/plant	3.111	1223.344**	22.078
7	Number of seeds *per* capsule	25.444	195.7159**	24.361
8	1000 seed weight (g)	0.0705	0.515**	0.033
9	Biological yield (Dry matter/plant in g)	4.855	27.680**	2.766
10	Harvest index (%)	5.586	213.112**	10.963
11	Seed yield/plant(g)	0.025	7.227**	0.126

P = 5%*, P = 1%** (P = Probability)

Table 2: Genetic correlation coefficient for eleven characters in sesame

Character	Days to 50% Flowering	Plant Height (cm)	Number of Branches/ Plant	Days to Maturity	Productive Branches/ Plant	Productive Capsules/ Plant	Number of Seeds /Capsule	1000 Seed Weight (g)	Biological Yield (dry Matter/ Plant gm)	Harvest Index (%)
Plant Height (cm)	-0.02									
Number of branches/ Plant	-0.06	0.58								
Days to Maturity	0.73	-0.49	-0.35							
Productive Branches/ Plant	-0.09	0.60	0.98	-0.34						
Productive Capsules/ Plant	-0.16	0.71	0.85	-0.47	0.83					
Number of Seeds /Capsule	-0.05	0.51	0.78	-0.21	0.77	0.65				
1000 Seed Weight (g)	-0.52	0.47	0.25	-0.46	0.23	0.37	0.28			
Biological Yield (dry Matter/ Plant gm)	-0.48	0.44	0.48	-0.61	0.49	0.43	0.32	0.40		
Harvest Index (%)	-0.11	0.35	0.60	-0.32	0.50	0.56	0.74	0.38	0.31	
Seed Yield/ Plant (g)	-0.31	0.43	0.67	-0.48	0.58	0.63	0.71	0.52	0.63	0.92

Table 3: Phenotypic correlation coefficient for eleven characters in sesame

Character	Days to 50% Flowering	Plant Height (cm)	Number of Branches/ Plant	Days to Maturity	Productive Branches/ Plant	Productive Capsules/ Plant	Number of Seeds /Capsule	1000 Seed Weight (g)	Biological Yield (dry Matter/ Plant gm)	Harvest Index (%)
Plant Height (cm)	0.02									
Number of Branches/ Plant	-0.03	0.48*								
Days to Maturity	0.70**	-0.45*	-0.28							
Productive Branches/ Plant	-0.07	0.50*	0.94**	-0.29						
Productive Capsules/ Plant	-0.14	0.67**	0.69**	-0.43*	0.69**					
Number of Seeds /Capsule	0.01	0.42	0.62**	-0.13	0.61**	0.53**				
1000 Seed Weight (g)	-0.44*	0.41	0.23	-0.38	0.19	0.32	0.25			
Biological Yield (dry Matter/ Plant gm)	-0.37	0.36	0.45*	-0.51*	0.43*	0.37	0.22	0.26		
Harvest Index (%)	-0.13	0.30	0.41	-0.31	0.36	0.50*	0.57**	0.35	0.13	
Seed Yield/ Plant (g)	-0.30	0.38	0.54**	-0.47*	0.49*	0.60**	0.57**	0.46*	0.53**	0.89**

*and ** = P < 0.05, P < 0.01, respectively

Table 4: Genotypic path coefficient analysis of eleven characters on seed yield in sesame

Character	Days to 50% Flowering	Plant Height (cm)	Number of Branches/ plant	Days to Maturity	Productive Branches/ Plant	Productive Capsules/ Plant	Number of Seeds /Capsule	1000 Seed Weight (g)	Biological Yield (dry Matter/ Plant gm)	Harvest Index (%)
Days to 50% Flowering	-0.2793	0.0046	0.0175	-0.2034	0.0258	0.0438	0.0144	0.1452	0.1348	0.0315
Plant Height (cm)	-0.0025	0.1501	0.0870	-0.0738	0.0894	0.1060	0.0759	0.0703	0.0662	0.0526
Number of Branches/ Plant	-0.0820	0.7579	1.3073	-0.4590	1.2853	1.1150	1.0141	0.3292	0.6326	0.7824
Days to Maturity	0.1798	-0.1214	-0.0867	0.2469	-0.0833	-0.1151	-0.0514	-0.1125	-0.1510	-0.0798
Productive Branches/ Plant	0.1173	-0.7555	-1.2479	0.4280	-1.2693	-1.0481	-0.9823	-0.2963	-0.6178	-0.6353
Productive Capsules/ Plant	0.0047	-0.0210	-0.0254	0.0139	-0.0246	-0.0298	-0.0195	-0.0111	-0.0129	-0.0166
Number of Seeds /Capsule	-0.0055	0.0542	0.0832	-0.0223	0.0830	0.0701	0.1073	0.0299	0.0339	0.0789
1000 Seed Weight (g)	0.0047	-0.0042	-0.0023	0.0041	-0.0021	-0.0034	-0.0025	-0.0090	-0.0036	-0.0034
Biological Yield (dry Matter/ Plant gm)	-0.1757	0.1604	0.1762	-0.2226	0.1772	0.1574	0.1152	0.1457	0.3640	0.1113
Harvest Index (%)	-0.0673	0.2095	0.3577	-0.1932	0.2991	0.3322	0.4398	0.2246	0.1827	0.5976
Seed Yield/ Plant (g)	-0.3059	0.4348	0.6666	-0.4815	0.5805	0.6281	0.7109	0.5160	0.6290	0.9194

Residual effect=0.0468, Rsquare=0.9978

Table 5: Phenotypic path coefficient analysis of eleven characters on seed yield in sesame

Character	Days to 50% Flowering	Plant Height (cm)	Number of Branches/ Plant	Days to Maturity	Productive Branches/ Plant	Productive Capsules/ Plant	Number of Seeds /Capsule	1000 Seed Weight (g)	Biological Yield (dry Matter/ Plant gm)	Harvest Index (%)
Days to 50% Flowering	0.0027	0.0001	-0.0001	0.0019	-0.0002	-0.0004	0.0000	-0.0012	-0.0010	-0.0004
Plant Height (cm)	-0.0020	-0.0891	-0.0431	0.0398	-0.0443	-0.0600	-0.0377	-0.0370	-0.0317	-0.0264
Number of Branches/ Plant	0.0019	-0.0293	-0.0606	0.0170	-0.0568	-0.0421	-0.0376	-0.0136	-0.0273	-0.0249
Days to Maturity	0.0174	-0.0111	-0.0070	0.0249	-0.0073	-0.0107	-0.0033	-0.0096	-0.0128	-0.0077
Productive Branches/ Plant	-0.0028	0.0213	0.0402	-0.0125	0.0429	0.0296	0.0262	0.0080	0.0184	0.0154
Productive Capsules/ Plant	-0.0132	0.0636	0.0656	-0.0404	0.0650	0.0945	0.0505	0.0305	0.0349	0.0473
Number of Seeds /Capsule	0.0000	0.0027	0.0040	-0.0009	0.0040	0.0035	0.0065	0.0016	0.0014	0.0037
1000 Seed Weight (g)	-0.0425	0.0405	0.0220	-0.0375	0.0181	0.0315	0.0241	0.0978	0.0257	0.0339
Biological Yield (dry Matter/ Plant gm)	-0.1565	0.1493	0.1886	-0.2145	0.1796	0.1548	0.0928	0.1103	0.4194	0.0532
Harvest Index (%)	-0.1036	0.2361	0.3276	-0.2461	0.2854	0.3986	0.4528	0.2759	0.1010	0.7960
Seed Yield/ Plant (g)	-0.2985	0.3841	0.5372	-0.4683	0.4865	0.5992	0.5743	0.4627	0.5280	0.8901

Residual effect = 0.1512 R square = 0.9771

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