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Character association and path coefficient analysis in sesame (*Sesamum indicum* L.) genotypes under foothill condition of Nagaland

PC Lalpantluangi and Pankaj Shah

Abstract
An experiment was conducted in randomized block design with three replications during kharif, 2016 at the experimental farm of School of Agricultural Sciences and Rural Development, Medziphema campus, Nagaland University to study the character association and path analysis among twenty one genotypes of sesame. Observations were recorded for various yield contributing traits. Correlation analysis revealed significant positive association of seed yield per plant with days to 80 percent maturity, number of capsules per plant and 1000 seed weight. Path coefficient analysis revealed that strover yield, days to 80 percent maturity, seeds per capsule and number of secondary branches per plant exerted positive direct effect on seed yield. Thus strover yield, days to 80 percent maturity, seeds per capsule and number of secondary branches per plant may be good selection criteria for seed yield per plant.

Keywords: Character association, path coefficient analysis, (*Sesamum indicum* L.)

1. Introduction
Sesame (*Sesamum indicum* L., Family Pedaliaceae), also called *til* and *gingelli*, is one of the oldest cultivated oilseed crops. Two alternative centres *viz*., East Africa (Ethiopia) or Asia (Indian Subcontinent or further east or central Asia) have been proposed for its origin. Sesame has been cultivated for centuries in India, Pakistan, Burma, Indo-China, China, Japan and Africa. In more recent times sesame has been introduced into Mexico, Central America, South America, and the U.S.A.

India is a major producer of this crop in the world and occupies well over 38 percent of total acreage and contributes about 26 percent of the total production. It is the sixth most important oil seed crop in India and having 1.80 million ha area with 0.76 mt production and productivity of 422 kg/ha (Anonymous, 2012) [2]. Rajasthan, Gujarat, Madhya Pradesh, Andhra Pradesh, West Bengal and Tamil Nadu put together constitutes nearly 72 percent of total area and 58 percent of total production of sesame in the country.

In northeast India in general and in Nagaland in particular quite a variety of sesame genotypes are available and most of them are being cultivated by farmers in small pockets. Sesame has been adopted well for cultivation in almost all the districts of Nagaland too at different elevations up to 1874 msl. Although, sesame was not given adequate recognition in the state as an important oilseed crop. Presently it has started to receive wide acceptance among farmers. On the basis of average of last three years data, in Nagaland, sesame was cultivated on 3540 ha that yielded about 2130 metric tonnes with productivity of 600 kg/ha. The sesame productivity of Nagaland is much higher than national average 400 kg/ha. This gap shows great promises for potential of sesame crop and contributes more share in terms of oil production in national pool.

Sesame is usually rich in oil (50 percent) and protein (18-20 percent), 13.5% carbohydrate and 5% ash. Nearly 78 percent of the sesame seed produced in India is used for oil extraction, 2.5 percent for planting purposes and the rest is used in confections and in religious Hindu ceremonies. Sesame seeds and oil are also used extensively in India. In most parts of the country, sesame seeds mixed with heated jaggery, sugar, or palm sugar is made into balls and bars similar to peanut brittle or nut clusters and eaten as snacks. In Manipur, black sesame is used in the preparation of *thoiding* and in *singju* (a kind of salad). *Thoiding* is prepared with ginger and chilli and vegetables are used in the spicy singju dish. In Assam, black sesame seeds are used to make *til pitha* and *tilor laru* (sesame seed balls) during Bihu festival.

Materials and Methods

The present study was carried out during *Kharif* 2016 at the Experimental farm of Department of Genetics and Plant Breeding, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema campus having an elevation of 310 m above mean sea level with a geographical location of $25^0$45'43" N latitudes and $93^0$53'04" E longitude, respectively.

The experimental material comprised of 21 genotypes of sesame; of which 15 genotypes are procured from The Project Coordinator, AICRP on Sesame & Niger, JNKVV, Jabalpur. Out of these, three are recommended for commercial cultivation in north east India. The variety TKG-21 is a national variety and used as a check. The remaining six genotypes are collected from AAU Experimental Centre, Diphu and are newly released varieties. The experiment was carried out following Randomized Block Design with three replications. The genotypes used in the experiment include GT-3, JTS-8, TKG-22, RT-54, RT-127, TKG-21, MT-75, NIRMALA, RT-125, RT-103, RT-346, PT-1, TKG-55, GT-10, VRI-2 and Nempo Soksu, Nempo Karjung, Nempo Charap, Nempo Thepo, ST-1683, Bahaubheti Local (collection from Diphu).

The data on different yield contributing quantitative characters such as Days to 50 percent flowering, Days to 80 percent maturity, Plant height, Internodal length, Stem height from base to first branch, Number of capsules per plant, Capsule length, Seeds per capsule, Number of primary branches per plant, Number of secondary branches per plant, 1000 seed weight, Strover yield, Oil content and Seed yield per plant were recorded.

The averages of data collected on 14 quantitative characters were statistically analysed for various statistical/genetic parameters. Phenotypic and genotypic correlation coefficients were worked out to study the interrelationship between various pairs of characters as suggested by Al-Jibouri *et al*. (1958) [1].

The path coefficient analysis was worked out by the formula applied by Dewey and Lu (1959) [5].

Results & Discussion

Correlation coefficients

The phenotypic and genotypic correlation coefficients for 14 characters in sesame genotypes were calculated and their significance was tested at 5% and 1% level of significance. The results are presented in Table (1 & 2).

At the genotypic level, number of days to 80 percent maturity (0.681), number of capsules per plant (0.655) and 1000 seed weight (0.472) showed significant positive correlation with seed yield per plant. Capsule length (0.349) also showed positive correlation with seed yield per plant. At the phenotypic level, significant positive correlation with seed yield per plant was

exhibited by number of capsules per plant (0.502). Days to 80 percent maturity (0.302), strover yield (0.268), 1000 seed weight (0.266) and number of secondary branches per plant (0.233), and capsule length (0.158) also revealed positive correlation with seed yield per plant.

At the genotypic level days to 50 percent flowering exhibited significant positive correlation with seeds per capsule (0.760), strover yield (0.749), plant height (0.681) and number of primary branches per plant (0.510) At the phenotypic level, this trait revealed significant positive correlation with seeds per capsule (0.610).

At genotypic level the trait days to 80 percent maturity exhibited significant positive correlation with seeds per capsule (0.473) and capsule length (0.469).

Plant height showed significant positive correlation with internodal length (0.575), stem height from base to first branch (0.573) and strover yield (0.469) at the genotypic level. At phenotypic level plant height exhibited significant positive correlation with strover yield (0.549) and internodal length (0.481).

At genotypic level, internodal length showed significant positive correlation with number of primary branches per plant (0.791) and 1000 seed weight (0.505). At genotypic level, stem height from base to first branch exhibited significant positive correlation with strover yield (0.446).

At both genotypic level and phenotypic level, number of capsules per plant exhibited significant positive correlation with number of secondary branches per plant (0.690 and 0.546 respectively).

At the genotypic level, capsule length revealed significant positive correlation with strover yield (0.689), seeds per capsule (0.617) and number of secondary branches per plant (0.501). At phenotypic level, capsule length exhibited significant positive correlation with number of seeds per capsule (0.430).

Number of seeds per capsule exhibited significant and positive correlation with strover yield (0.537) at the genotypic level.

At genotypic as well as phenotypic level, number of secondary branches per plant showed significant positive correlation with strover yield (0.517 and 0.450; respectively).

Correlation coefficient analysis measures the mutual relationship between various characters and is used to determine the component character on which selection can be done for improvement in yield (Sumathi and Muralidharan, 2010) [23]. During this study, correlation between the 14 characters was studied at the genotypic level and phenotypic level.

In the present investigation number of capsules per plant, days to 80 percent maturity and 1000 seed weight exhibited strong positive correlation with seed yield. Sumathi and Muralidharan (2010) [23] also reported similar findings. Mohammed and Firew (2015) [15, 16], Noor-ul *et al*. (2001) [18], Sankar and Kumar (2003) [2, 20], Gnanasekaran *et al*. (2008) [8], Engin *et al*. (2010), Goudappagoudra *et al*. (2011) [9], Solomon and Peter (2012) [22] and Ismaila and Usman (2014) [10] also observed that number of capsules per plant and 1000 seed weight exhibited strong positive correlation with seed yield. Gangadhara *et al*. (2012) [7], Salah and Abubakri (2012) [19], Vanishree *et al*. (2013) and Mohammed *et al*. (2015) [16, 15] also reported that number of capsules per plant and days to 80 percent maturity had significant positive correlation with seed yield. Thiyagu *et al*. (2007) [24], Iwo *et al*. (2007) [11], Kumhar *et al*. (2008) [13], Bharathi and Vivekanandan (2009) [4] and Meenakumari and Ganesamurthi (2015) [14] also reported significant positive correlation of number of capsules per plant with seed yield. Mohanlal *et al*. (2016) [17] also reported that days to 80 percent maturity had significant positive correlation with seed yield.

Kumar *et al*. (2012) [12] observed that the estimates of genotypic correlations were higher than those of phenotypic ones in all the cases of grain yield. In the present study higher estimates for genotypic correlation were observed for days to maturity, number of capsules, capsule length and 1000 seed weight.

Therefore, from the correlation analysis it can be confirmed that number of capsules per plant, 1000 seed weight and days to 80 percent maturity were found to be important yield contributing traits.

Path coefficient analysis

Path coefficient analysis was carried out to study the direct and indirect effects of different yield contributing characters on seed yield. The results of various causes influencing yield are presented in Table (3).

Maximum positive direct effect on seed yield was contributed by strover yield (0.644) followed by that of number of days to 80 percent maturity (0.444), seeds per capsule (0.380) and number of secondary branches per plant (0.258). Number of days to 50 percent flowering exhibited maximum positive indirect effect on seed yield *via* strover yield (0.482) followed by seeds per capsule (0.289). Number of days to 80 percent maturity exerted maximum positive indirect effect on seed yield *via* plant height (0.327) followed by stem height from base to first branch (0.205).

Plant height exhibited maximum positive indirect effect on seed yield *via* 1000 seed weight (0.320) followed by strover yield (0.302). Internodal length exerted maximum positive indirect effect on seed yield *via* 1000 seed weight (0.211), followed by capsule length (0.124). Stem height from base to first branch exerted maximum positive indirect effect on seed yield *via* capsule length (0.497), followed by strover yield (0.287).

Number of capsules per plant exerted maximum positive indirect effect on seed yield *via* stem height from base to first branch (0.725) which is followed by number of secondary branches per plant (0.178). Capsule length exhibited maximum positive indirect effect on seed yield *via* strover yield (0.443), followed by stem height from base to first branch (0.396).

Number of seeds per capsule exerted maximum positive indirect effect on seed yield *via* strover yield (0.346), followed by number of days to 80 percent maturity and oil content (0.210).

Number of primary branches per plant exerted maximum positive indirect effect on seed yield *via* strover yield (0.188) followed by 1000 seed weight (0.156).

Number of secondary branches per plant showed maximum positive indirect effect on seed yield *via* stem height from base to first branch (0.569) followed by strover yield (0.333).1000 seed weight exhibited maximum positive indirect effect on seed yield *via* plant height (0.624) followed by capsule length (0.308). Strover yield exhibited maximum positive indirect effect on seed yield *via* 1000 seed weight (0.251) followed by number of seeds per capsule (0.204).

Oil content exhibited maximum positive indirect effect on seed yield *via* plant height (0.233) followed by stem height from base to first branch (0.220).

Discussion

Selection merely based on yield is not effective. Path co-efficient analysis provides an efficient means of partitioning of correlation co-efficient into direct and indirect effects of the component characters. Selection on the basis of direct and indirect effects is much more useful than selection for yield *per se* alone (Bharathi and Vivekanandan, 2009) [4]. Path analysis revealed that strover yield, days to 80 percent maturity, seeds per capsule and secondary branch have positive direct effect on seed yield.

Number of secondary branches per plant revealed positive direct effect on seed yield. Bharathi and Vivekanandan (2009) [4] also observed that number of branches per plant had high positive direct effect on seed yield per plant. This finding is also in agreement with those of Bamrotiya *et al*. (2016) [3] and Saxena and Bisen (2016) [21].

Seeds per capsule have also reported to have positive direct effect on seed yield. Goudappagoudra *et al*. (2011) [9] also reported that number of seeds per capsule had positive direct effect on seed yield.

The highest positive direct effect of strover yield and days to maturity on seed yield may be attributed to more vegetative growth of plants under foothill condition of Nagaland which resulted due to continuous and evenly distributed rainfall coupled with moderate temperature during the crop growth period. As evident from the meteorological data that even in the month of maturity and subsequent harvesting stage; approximately 35 mm rainfall was received that prolonged the maturity period thereby delaying the harvesting date to 8-12 days than that of other parts of the country.

Residual effect

The estimated residual effect was 0.300.

Table 1: Genotypic correlation among fourteen characters in sesame.

Characters	Days to 50% flowering	Days to 80% maturity	Plant height	Internodal length	Stem height from base to 1st branch	No. of capsules/ plant	Capsule length	No. of seeds/ capsule	Primary branches/ plant	Secondary branches/ plant	1000 seed weight	Strover yield	Oil content	Seed yield/ plant
Days to 50% flowering	1	0.154	0.298	0.173	0.187	-0.267	0.155	0.610**	0.255	0.082	-0.502*	0.272	-0.089	-0.280
Days to 80% maturity		1	-0.289	-0.156	-0.151	0.027	0.056	0.258	0.033	-0.054	0.180	0.163	-0.050	0.302
Plant height			1	0.481*	0.205	0.116	0.162	0.213	0.082	0.339	-0.453*	0.549**	-0.110	-0.056
Internodal length				1	-0.069	-0.031	0.124	-0.034	0.210	0.207	-0.259	0.218	0.079	-0.040
Stem height from base to first branch					1	-0.548**	-0.250	0.074	0.074	-0.397	0.013	-0.192	-0.188	-0.478*
Capsules/ plant						1	0.165	-0.193	-0.180	0.546**	0.000	0.183	0.116	0.502*
Capsule length							1	0.430*	-0.023	0.191	-0.110	0.176	-0.040	0.158
Seeds/capsule								1	0.054	-0.002	-0.334	0.283	-0.321	-0.041
Primary branches/plant									1	-0.057	-0.253	0.027	0.066	-0.158
Secondary branches/ plant										1	-0.291	0.450*	0.074	0.233
1000 seed weight											1	-0.324	0.004	0.266
Strover yield												1	0.033	0.268
Oil content													1	-0.177

Table 2: Phenotypic correlation among fourteen characters in sesame.

Characters	Days to 50% flowering	Days to 80% maturity	Plant height	Internodal length	Stem height from base to 1st branch	No. of capsules/ plant	Capsule length	No. of seeds/ capsule	Primary branches/ plant	Secondary branches/ plant	1000 seed weight	Strover yield	Oil content	Seed yield/ plant
Days to 50% flowering	1	0.154	0.298	0.173	0.187	-0.267	0.155	0.610**	0.255	0.082	-0.502*	0.272	-0.089	-0.280
Days to 80% maturity		1	-0.289	-0.156	-0.151	0.027	0.056	0.258	0.033	-0.054	0.180	0.163	-0.050	0.302
Plant height			1	0.481*	0.205	0.116	0.162	0.213	0.082	0.339	-0.453*	0.549**	-0.110	-0.056
Internodal length				1	-0.069	-0.031	0.124	-0.034	0.210	0.207	-0.259	0.218	0.079	-0.040
Stem height from base to first branch					1	-0.548**	-0.250	0.074	0.074	-0.397	0.013	-0.192	-0.188	-0.478*
Capsules/ plant						1	0.165	-0.193	-0.180	0.546**	0.000	0.183	0.116	0.502*
Capsule length							1	0.430*	-0.023	0.191	-0.110	0.176	-0.040	0.158
Seeds/capsule								1	0.054	-0.002	-0.334	0.283	-0.321	-0.041
Primary branches/plant									1	-0.057	-0.253	0.027	0.066	-0.158

Secondary branches/ plant										1	-0.291	0.450*	0.074	0.233
1000 seed weight											1	-0.324	0.004	0.266
Strover yield												1	0.033	0.268
Oil content													1	-0.177

Table 3. Direct (diagonal) and indirect effect of yield components on seed yield at genotypic level in sesame genotypes.

Characters	**Days to 50% flowering**	**Days to 80% maturity**	**Plant height**	**Internodal length**	**Stem height from base to first branch**	**No. of capsules/ plant**	**Capsule length**	**Seeds/ capsule**	**Primary branches/ plant**	**Secondary branches/ plant**	**1000 seed weight**	**Strover yield**	**Oil content**	**Seed yield/ plant**
Days to 50% flowering	**-0.480**	0.031	-0.554	-0.015	-0.230	0.107	-0.241	0.289	-0.214	0.051	0.255	0.482	0.051	-0.466
Days to 80% maturity	-0.033	0.444	0.327	0.040	0.205	-0.014	-0.500	0.180	-0.048	-0.074	-0.118	0.198	0.073	0.680
Plant height	-0.327	-0.178	-0.814	-0.051	-0.486	0.025	-0.085	0.140	-0.061	0.097	0.320	0.302	0.150	-0.968
Internodal length	-0.082	-0.202	-0.468	-0.089	-0.108	0.038	0.124	-0.033	-0.332	0.079	0.211	0.121	-0.091	-0.835
Stem height from base to first branch	-0.130	-0.107	-0.466	-0.011	-0.848	0.262	0.497	0.075	-0.013	-0.173	-0.019	0.287	0.136	-0.512
No. of capsules/ plant	0.168	0.020	0.067	0.011	0.725	-0.307	-0.159	-0.121	0.089	0.178	0.015	0.012	-0.047	0.654
Capsule length	-0.108	0.208	-0.065	0.010	0.396	-0.045	-1.066	0.235	0.034	0.129	0.121	0.443	0.056	0.349
No. of seeds/ capsule	-0.364	0.210	-0.300	0.007	-0.168	0.097	-0.658	0.380	-0.108	-0.017	0.163	0.346	0.210	-0.200
Primary branches/ plant	-0.245	0.050	-0.119	-0.070	-0.028	0.065	0.087	0.097	-0.420	0.022	0.156	0.188	-0.070	-0.285
Secondary branches/ plant	-0.096	-0.127	-0.306	-0.027	0.569	-0.212	-0.534	-0.025	-0.035	0.258	0.152	0.333	0.028	-0.022
1000 seed weight	0.293	0.125	0.624	0.045	-0.039	0.011	0.308	-0.149	0.157	-0.094	-0.418	-0.387	-0.006	0.472
Strover yield	-0.359	0.136	-0.382	-0.016	-0.378	-0.006	-0.734	0.204	-0.123	0.133	0.251	0.644	0.074	-0.555
Oil content	0.047	-0.061	0.233	-0.015	0.220	-0.028	0.114	-0.152	-0.056	-0.014	-0.005	-0.090	-0.525	-0.333

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