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

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ABSTRACT

This study was conducted to determine the genetic variability and character association in 13 sesame (*Sesamum indicum*) accessions. The accessions were evaluated in replicated field experiments at the Department of Crop Science Teaching and Research Field, University of Nigeria, Nsukka under two planting seasons. The result showed significant differences among the accessions in most of the traits studied. The genotypic and heritability estimates were high for all the growth and yield attributes, indicating that these traits have high transmitting ability to subsequent generations. The highest genetic and phenotypic variance were observed in number of seeds/plant (5389.3 and 5391.3) in 2009 with number of capsules/plant (223.64 and 226.03) in 2010. However, for genetic and phenotypic coefficients of variation, the highest were observed in seed yield/ha and seed yield/plant (37.80 and 40.01) in 2009 while seed yield/plant (40.54 and 40.56) gave the highest in 2010. Apart from number of days to emergence in 2009 planting season, high heritability values were obtained on all the traits during the two planting seasons indicating that selection for those traits would be very efficient. The correlation matrix showed that seed yield/plant correlated positively and significantly with number of leaves, plant height, number of branches, stem girth, number of flowers/plant, number of capsules/plant, number of seeds/capsules, capsule length, capsule weight/plant, 1000-seed weight and number of seeds/plant. This indicates that increase in these traits will ultimately increase seed yield.

Keywords: heritability, selection, sesame, variation

INTRODUCTION

Sesame (*Sesamum indicum* (L.) Walp.) is an important tropical oil seed crop (Ashri 1998). It is widely grown in Northern and Central parts of Nigeria as an excellent source of high quality oil, rich in carbohydrate, protein, calcium and phosphorus (NCRI 2005). Global production is put at 2.4 million metric tonnes with China and India as leading producers. Nigeria is the 5th largest producer of the commodity in the world with an estimated production of 120,000 metric tones annually.

Sesame seed is traditionally used for direct consumption as well as for confectioneries, cookies, cake, margarine and in bread making. It is also useful in the manufacture of soaps, cosmetics, perfumes, insecticides and pharmaceutical products. Sesame contains high levels of antioxidants such as sesamol, sesamin, sesamolin and sesaminol. Therefore, sesame oil is called the queen of the vegetable oils (ASGA 2011). The high levels of unsaturated (UFA) and polyunsaturated fatty acids (PUFAs) increase the quality of the oil for human consumption (Nupur *et al.* 2010). Sesame oil has been investigated as a source for biodiesel and found to give a product with fuel properties in parity with mineral diesel but with superior environmental performance (Ahmed *et al.* 2010). The unique property as a semi-drying oil makes it suitable for use in production of alkyl resin for paint formulation (Bedigian 2003). The important and useful contribution of this crop in boosting our local, national and international economies has not been fully explored. Information on the genetic diversity on sesame is limited as well. There is also need to understand the association and contribution of growth and yield traits to seed yield in sesame. Yield is the most essential trait in crops and shows interaction of the environment on growth and development processes in the entire life cycle of plants (Quarrie *et al.* 2006). Seed yield therefore is directly determined by yield related traits and is greatly influenced by both genetic and environmental factors (Wattoo *et al.* 2009). Poehlman (1991) and Singh and Singh (1995) reported that selection based on yield components is advantageous if information on the different yield component traits are available. However, despite the nutritional value, historic and cultural importance, research on sesame has been scanty. The objective of this study was therefore to estimate the genetic variation in growth and yield attributes and to identify especially the yield-determining traits of utmost importance that could be accorded substantial value in selection. This will enable breeders to design breeding methods aimed at improving the crop.

MATERIALS AND METHODS

Field experiments were conducted in 2009 and 2010 seasons in the Department of Crop Science, Faculty of Agriculture, University of Nigeria, Nsukka (Lat. 06° 52'N; Long. 07° 24'E; Alt. 447.2 m a.s.l.). The experimental material comprised 13 sesame accessions namely: Adaukiari, Chimkwale yellow, 34-4-1, Cameroun white, Parchequeno, E8, Aliade, Kachia, Jigawa, Chimkwale, 69-1-9, Yobe gadaka and NCRI BEN 02M. These were sourced from the germplasm of National Cereal Research Institute (NCRI) Badeggi, Nigeria. The experiment was laid out in a Randomized Complete Block Design (RCBD). Each of the accession served as a treatment and was replicated three times. Total land area of 45 m × 8 m was used. The plot size was 3 m × 2 m with 0.5 m space between the plots and 1 m space between blocks. Sowing was done in late June for both years by drilling. Thinning commenced 3 WAP to give an inter row and intra row spacing of 60 cm × 30 cm. Standard cultural practices were adopted for optimum crop growth and development. Three plants from each plot were selected randomly and assessed for 18 quantitative agronomic traits and data were

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taken on number of days to emergence, number of leaves, plant height (cm), number of branches, stem girth (mm), number of lodged plants/plot, number of days to flower bud initiation, number of days to 50% flowering, number of days to maturity, number of flowers/plant, number of capsules/plant, number of seeds/capsule, number of capsules/leaf axils, capsule diameter (mm), capsule length (cm), capsule weight/plant (g), 1000-seed weight (g), seed yield/plant (g), number of seeds/plant and seed yield (kg/ha).

Data analysis

Data collected were subjected to analysis of variance (ANOVA) to understand the level of variability existing among the accessions using Genstat Discovery Edition 3 (Genstat 2007) software. Estimates of phenotypic and genotypic and error variances were done according to the procedure described by Uguru (1998). Broad sense heritability (Hbs) was estimated following the procedure described by Poehlman (1987).

Phenotypic and genotypic coefficients of variation (PCV and GCV) were estimated using the method described by Burton and Devane (1953).

Expected genetic gain (G_s) under selection for each trait was calculated according to Allard (1980).

Correlations were calculated to examine relationships among traits using SPSS for windows version 16.0 (SPSS, Inc., Chicago, IL).

RESULTS

Genetic parameter estimates on growth and yield attributes of 13 sesame accessions in 2009 planting season are presented in **Table 1**. The table showed that the magnitude of genotypic variance was higher than the environmental variance for all the traits. Their phenotypic and genotypic variances were close to each other except for number of days to emergence. The PCV was highest for seed yield/plant (40.01%) followed by seed yield/hectare, number of seeds/plant, number of branches, capsule weight/plant, number of seeds/capsule and number of capsules/plant with 37.91, 37.60, 27.37, 25.57, 23.20 and 22.87%, respectively. The PCV for number of days to emergence was 17.64%, followed by stem girth (16.29%), number of leaves (14.86%), number of flowers/plant (7.74%), number of days to 50% flowering (16.22%) and number of days to flower bud initiation (15.28%). Low PCV values came from plant height, capsule length, capsule diameter, number of days to maturity and 1000-seed weight with 10.83, 6.30, 5.97, 3.18 and 1.42%, respectively. The highest estimate of GCV was observed on seed yield/ha (37.80%) followed by number of seeds/plant (37.58%), seed yield/plant (36.72%), number of branches (26.97%), capsule weight/plant (25.29%) while the lowest was from 1000 seed weight (1.38%). Number of seeds/capsule, number of capsules/plant, stem girth, number of days to 50% flowering, number of leaves, number of days to flower bud initiation, plant height, number of flowers/plant, capsule length, capsule diameter and number of days to maturity recorded 22.86, 22.72, 16.28, 15.61, 14.77, 14.06, 10.37, 7.67, 6.20, 5.93 and 2.85%, respectively. High broad sense heritability estimates were observed for all the growth and yield attributes. The expected genetic advance was measured at 5% selection intensity and selection differential of 2.06. The result presented in **Table 1** showed that expected genetic gain was high on all the growth and yield attributes except for 1000-seed weight and capsule length.

The genetic parameter estimates on growth and yield attributes of 13 Sesame accessions in 2010 planting season are presented in **Table 2**. The table showed that the degree of genotypic variance for all the growth and yield attributes was higher than the environmental variance; and closer to their phenotypic variances. The PCV was highest for seed yield/plant (40.56%), followed by number of seeds/plant (40.45%), seed yield/ha (37.91%) and number of capsules/plant (25.09%). Number of seeds/capsule, number of days to emergence, capsule weight/plant, number of branches, number of days to 50% flowering, stem girth, plant height, number of days to flower bud initiation, number of leaves and capsule length recorded PCV as 19.15, 17.28, 17.20, 11.71, 11.37, 10.96, 9.76, 7.84, 6.51 and 6.14%, respectively. Low PCV values came from capsule diameter, number of days to maturity, number of flowers/plant and 1000-seed weight with 4.77, 4.13, 0.62 and 1.69%, respectively. The highest estimate of GCV was also observed on seed yield/plant (40.54%), followed by number of seeds/plant (40.44%), seed yield/ha (37.80%) and number of capsules/plant (24.15%) while the lowest was from 1000-seed weight (1.42%). Number of seeds/capsule, capsule weight/plant, number of days to emergence, number of branches, stem girth, plant height, number of days to 50% flowering, number of days to flower bud initiation, number of leaves, capsule length, capsule diameter, number of days to maturity and number of flowers/plant recorded 19.01, 16.56, 15.32, 11.68, 10.84, 9.75, 9.73, 7.74, 6.49, 6.10, 4.76, 3.76 and 0.61%, respectively. High broad sense heritability estimates were observed for all the growth and yield attributes. The

Table 1 Some genetic estimate on growth and yield attributes for 2009 planting season.

Trait	Mean	$\sigma^2 g$	σ^{2e}	$\sigma^2 ph$	GCV (%)	PCV (%)	Hbs (%)	Gs
NDE	4.538	0.333	0.31	0.6410	12.71	17.64	51.95	0.85
NL	138.42	418.06	5.49	423.55	14.77	14.86	98.70	41.84
PH	93.90	94.99	8.49	103.48	10.37	10.83	91.79	19.23
NB	6.795	3.36	0.10	3.46	26.97	27.37	97.10	36.72
SG	9.88	2.58	0.01	2.59	16.28	16.29	99.82	3.31
NDFBI	28.77	16.37	2.97	19.34	14.06	15.28	84.62	7.67
ND50% F	43.38	45.86	3.69	49.55	15.61	16.22	92.54	13.41
NDM	101.54	8.427	2.03	10.45	2.85	3.18	80.61	5.36
NFP	172.15	174.7	3.2	177.9	7.67	7.74	98.23	26.98
NCP	65.23	219.7	2.90	222.6	22.72	22.87	98.72	30.34
NSC	28.27	41.79	1.24	43.03	22.86	23.20	97.13	13.12
CD	6.27	0.138	0.02	0.140	5.93	5.97	98.86	0.76
CL	2.54	0.025	0.01	0.026	6.20	6.30	96.57	0.32
CWP	26.37	44.50	0.96	45.46	25.29	25.57	97.88	13.59
1000SW	4.45	0.38	0.02	0.40	1.38	1.42	97.18	1.27
SYP	8.70	10.21	1.91	12.12	36.72	40.01	91.77	6.58
NSP	1952.8	5389.3	2.00	5391.3	37.59	37.60	99.96	151.1
SY/ha	483.63	334.4	2.10	336.3	37.80	37.91	99.42	37.56

NDE = number of days to emergence, NL = number of leaves, PH = plant height (cm), NB = number of branches, SG = stem girth (mm), NLPP = number of lodged plants/plot, NDFBI = number of days to flower bud initiation, ND50%F = number of days to 50% flowering, NDM = number of days to maturity, NFP = number of flowers/plant, NCP = number of capsules/plant, NSC = number of seeds/capsule, NCL = number of capsule/leaf axils, CD = capsule diameter (mm), CL = capsule length (cm), CWP = capsule weight/plant (g), 1000SW = 1000-seed weight (g), SYP = seed yield/plant (g), NSP = number of seeds/plant, SY Kg/ha = seed yield in kilogram/hectare.

Table 2 Some genetic estimate on growth and yield attributes for 2010 planting season.

Trait	Mean	σ^2g	σ^{2e}	σ^2ph	GCV (%)	PCV (%)	Hbs	Gs
NDE	4.69	0.51	0.14	0.65	15.32	17.28	78.57	1.30
NL	154.9	100.08	0.63	100.71	6.49	6.51	99.38	20.54
PH	100.4	95.92	1.92	96.00	9.75	9.76	99.91	20.16
NB	8.156	0.908	0.005	0.913	11.68	11.71	99.40	1.95
SG	11.81	1.64	0.03	1.67	10.84	10.96	97.77	2.60
NDFBI	30.08	5.43	0.14	5.57	7.74	7.84	97.48	4.73
ND50% F	43.77	18.15	6.62	24.77	9.73	11.37	73.27	7.51
NDM	103.08	15.05	3.09	18.14	3.76	4.13	82.96	7.27
NFP	176.95	0.222	0.002	0.224	0.61	0.62	99.19	0.96
NCP	67.95	223.64	3.61	226.03	24.15	25.09	96.56	29.90
NSC	27.71	31.92	0.48	32.40	19.01	19.15	98.51	11.55
CD	6.31	0.0903	0.0002	0.0905	4.76	4.77	99.76	0.61
CL	2.51	0.0234	0.0001	0.0235	6.10	6.14	98.65	0.31
C WP	27.61	20.911	1.55	22.56	16.56	17.20	92.69	9.06
1000SW	4.45	0.004	0.002	0.0057	1.42	1.69	84.02	0.13
SYP	9.26	14.08	0.01	14.09	40.54	40.56	99.92	7.72
NSP	2077.6	70.62	0.03	70.65	40.44	40.45	99.96	17.30
Sy/ha	483.6	33.4	0.2	33.6	37.80	37.91	99.42	11.87

NDE = number of days to emergence, NL = number of leaves, PH = plant height (cm), NB = number of branches, SG = Stem girth (mm), NLPP = number of lodged plants/plot, NDFBI = number of days to flower bud initiation, ND50%F = number of days to 50% flowering, NDM = number of days to maturity, NFP = number of flowers/plant, NCP = number of capsules/plant, NSC = number of seeds/capsule, NCL = number of capsule/leaf axils, CD = capsule diameter (mm), CL = capsule length (cm), CWP = capsule weight/plant (g), 1000SW = 1000-seed weight (g), SYP = seed yield/plant (g), NSP = number of seeds/plant, SY Kg/ha = seed yield in kilogram/hectare.

Table 3 Correlation coefficient among the growth attributes and seed yield/plant in sesame accessions.

	SYP	NDE	NL	PH	NB	SG
SYP	1.00					
NDE	-0.077	1.00				
NL	0.531**	0.123	1.00			
PH	0.700**	0.340*	0.618**	1.00		
NB	0.379*	0.253	0.424**	0.424**	1.00	
SG	0.437**	0.115	0.436**	0.542**	0.204	1.00

NDE = number of days to emergence, NL = number of leaves, PH = plant height (cm), NB = number of branches, SG = Stem girth (mm), SYP = seed yield per plant, * = significant correlation ** = Highly significant correlation.

result presented in **Table 2** showed that expected genetic gain was high on all the growth and yield attributes except for 1000-seed weight and capsule length.

Correlation

The correlation coefficient (r) of the growth traits are presented in **Table 3**. The table revealed that seed yield/plant was highly significant and positively correlated with number of leaves, plant height, number of branches and stem girth. This suggested that increase in the above traits would lead to an increase in seed yield. A negative but non-significant correlation however occurred between seed yield/plant and number of days to emergence.

Correlation coefficient of the yield traits are presented in **Table 4**. The table showed that seed yield/plant had a perfect correlation with number of seeds/plant (r = 1.00**) and seed yield/ha (r = 1.00**). Highly significant and positive correlation was observed between seed yield/plant with number of flowers/plant (r = 0.848**), number of capsules/plant (r = 0.904**), number of seeds/capsule (r = 0.883**), capsule length (r = 0.669**) and capsule weight/plant (r = 0.659**). Seed yield/plant also correlated positively and significantly with 1000-seed weight (r = 0.368*). A positive but non-significant relationship was noticed between seed yield and number of days to maturity (r = 0.146). However, negative and significant correlations were recorded between seed yield/plant with capsule diameter (r = -0.343*), whereas non-significant negative relationship was recorded when seed yield/plant was correlated with number of days to flower bud initiation (r = -0.312) and number of days to 50% flowering (r = -0.315).

DISCUSSION

Genetic variation was observed to have a major control of the differences that existed among the accessions as indicated by the high degree of genetic variation in the total variation. Nausherwan *et al.* (2008) reported that an effective breeding program largely depends upon genetic variability. However, there are indications that some of the characters had genotype by environment interaction. This is the reason for the higher magnitude of the phenotypic coefficient of variation relative to the corresponding genetic coefficient of variation in most of the traits evaluated. The coefficient of variation compares the relative amount of variability among the traits and measures the potential for gains by selection. Apart from number of days to emergence, the magnitude of genetic variance for all the traits measured in both years was far higher than the environmental variance since their phenotypic and genotypic variance were close to each other. It indicates that the genotypic component was the major contributor to the total variance for these traits during the two planting seasons. This means that those traits have broad genetic base hence improvement can be achieved through selection.

A narrow range of difference between PCV and GCV was recorded for almost all the traits indicating that the above traits are mostly governed by genetic factors with minimal environmental influence on the phenotypic expression of the traits. Hence selection of these traits on the basis of phenotypic value may be effective. Nausherwan *et al.* (2008) reported that the polygenic variation may be phenotypic, genotypic or environmental and the relative values of these three types of coefficient give an idea about magnitude of the variability. Conversely, an obvious difference between GCV and PCV was observed in number of days to emergence (12.71 and 17.64) indicating high environmental influence on the trait thereby reducing possible response to selection on phenotypic basis. Genetic variation could further be investigated with the help of heritability estimates. This measures the heritable portion of the total variation and also implies high potential for improvement through selection. High broad sense heritability estimates were observed for all the traits except number of days to emergence. Reddy *et al.* (2001) and Krishnaiah *et al.* (2002) reported that high heritability was observed for seed yield/plant, number of primary branches/plant, number of capsules/plant, number of seeds/capsule, plant height and days to 50% flowering. This indicates the lesser influence of environment in expression of these characters and prevalence of

Table 4 Correlation coefficient among the yield attributes and seed yield/plant in sesame accessions.

	SYP	NDFBI	ND50% F	NDM	NFP	NCP	NSC	CD	CL	CWP	1000SW	NSP	SY/ha
SYP	1.00												
NDFBI	-0.312	1.00											
ND50% F	-0.315	0.790**	1.00										
NDM	0.146	0.244	0.269	1.00									
NFP	0.848**	-0.406*	-0.453**	0.297	1.00								
NCP	0.904**	-0.420**	-0.479**	0.266	0.964**	1.00							
NSC	0.883**	-0.377*	-0.523**	-0.080	0.706**	0.799**	1.00						
CD	-0.343*	0.266	0.272	0.082	-0.329*	-0.336*	-0.258	1.00					
CL	0.669**	-0.266	-0.154	0.097	0.494**	0.528**	0.523**	-0.451**	1.00				
CWP	0.659**	-0.188	-0.476**	0.216	0.737**	0.782**	0.661**	-0.086	0.040	1.00			
1000SW	0.368*	-0.263	-0.324*	0.239	0.378*	0.394*	0.361*	0.202	0.089	0.435**	1.00		
NSP	1.000**	-0.310	-0.313	0.144	0.848**	0.905**	0.883**	-0.347*	0.671**	0.658**	0.359*	1.00	
SY/ha	1.000**	-0.313	-0.315	0.146	0.849**	0.904**	0.883**	-0.343*	0.669**	0.659**	0.367*	1.000**	1.00

NDFBI = number of days to flower bud initiation, ND50% F = number of days to 50% flowering, NDM = number of days to maturity, NFP = number of flowers/plant, NCP = number of capsules/plant, NSC = number of seeds/capsule, NCL = number of capsule/leaf axils, CD = capsule diameter (mm), CL = capsule length (cm), CWP = capsule weight/plant (g), 1000SW = 1000-seed weight (g), SYP = seed yield/plant (g), NSP = number of seeds/plant, SY Kg/ha = seed yield in kilogram/hectare * = Significant correlation ** = Highly significant correlation.

additive gene action in their inheritance which suggests reduced environmental influence thereby validating the results obtained with the GCV values. Laurentin and Karlovsky (2006) reported that sesame has a large genetic variability. This attribute should be taken into account when planning conservation strategies or when sesame variability is being used in breeding programs. The comparatively low GCV (12.71) and heritability (51.95) values obtained for number of days to emergence is not surprising since seedling emergence is influenced by several environmental factors. Therefore direct selection for number of days to emergence may not produce the desired result. Low GCV and heritability values have been reported by Vange and Egbe (2009) in pigeon pea. The estimated expected genetic advance in selection in the various traits is a confirmation that improvement could be made on the accessions through selection.

Seed yield/plant was positively correlated with some traits like number of leaves, plant height, number of branches, stem girth, number of flowers/plant, number of capsules/plant, number of seeds/capsules, capsule length, capsule weight/plant, 1000-seed weight and number of seeds/plant. This agrees with Mishra *et al.* (1995) and Ranganatha *et al.* (1994) who reported a highly significant correlation between seed yield and number of capsules/plant, plant height, 1000-seed weight and number of branches/plant in sesame. This is an indication that higher values for these traits can increase the seed yield/plant. The correlation between seed yield/plant and number of flowers/plant, number of capsules/plant, number of seeds/capsules, capsule length and capsule weight/plant were highly significant and positive which also agrees with Farshadfar and Farshadfer (2008), and Manora and Manara (1988). Iqbal *et al.* (2003) in his findings reported that number of flowers/plant and number of pods/plant are important yield component in legumes. The positive and significant association of seed yield/plant and the aforementioned yield-determining traits revealed that higher values of those traits would contribute to more seed yield/plant. These results on correlation agreed with the previous reports of Pathak and Dixit (1992) for black-seeded sesame. A positive association of yield with the number of capsules was also reported by Varisai and Stephen (1964) and Gupta and Gupta (1977). Hence, for effective yield improvement in sesame, selection should be made for higher values of those traits. The negative association of seed yield/plant with days to emergence, number of days to flower bud initiation and number of days to 50% flowering gave an understanding that accessions with shorter days to emergence, number of days to flower bud initiation and 50% flowering would give an increase in seed yield.

In conclusion, the degree of genetic variability observed in the study assures substantial improvement through selection of the relevant growth and yield traits. Number of flowers/plant, number of capsules/plant, number of seeds/capsule, capsule length and number of seeds/plant were the most important seed yield component and should be strongly selected for any breeding work aimed at improving sesame.

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