International Journal of Agricultural Science Research Vol. 2(2), pp. 054-059, February 2013
Available online at http://www.academeresearchjournals.org/journal/ijasr

Full Length Research Paper

Variability of yield and some morphological traits in some sesame (*Sesamum indicum* L.) genotypes under rain-fed conditions

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Accepted 9 February, 2013

An experiment was carried out at Gedarif Agricultural Research Station, Sudan, for two consecutive rainy seasons (2009 and 2010) to estimate the phenotypic and genotypic coefficients of variation, heritability in broad sense, genetic advance and genetic advance as percentage of the mean for yield and other growth attributes in seven sesame genotypes. A randomized complete block design with four replicates was used. The parameters were days to 50% flowering, days to maturity, plant height, number of capsules/plant, seed yield/plant (g) and seed yield (kg/ha). A wide range of variability was detected among the genotypes for all characters in both seasons. The earliest maturing genotype combined over two seasons (77.00 days) was SPS2003T10 whereas the latest one (87.10 days) was Gedarif -1. The lowest yielder genotype (361.00 Kg/ha) was Ziraa-9 whereas the highest yielder (591 Kg/ha) was Gedaref-1 which out-yielded the overall mean yield by 28.43% in the first season and by 23.88% in the second season. High heritability coupled with low genetic advance was recorded for days to 50% flowering, days to maturity and plant height which indicate dominant and epistatic gene action while low to moderate heritability with high genetic advance was recorded for the yield and its components which indicate the additive nature of inheritance. Therefore, direct simple selection may improve the morphological traits of the crop, whereas, other mechanisms may be needed to improve the seed yield and its components.

Key words: Sesame, genotypes, phenotypic, variability, heritability, genetic advance.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is a diploid species (2n=26) and a member of the Pedaliaceae family. It is known as beniseed, gingelly, sim-sim, and is grown throughout the tropics and sub-tropics from 25°N to 25°S (Weiss, 1971). Sesame was domesticated on the Indian subcontinent (Bedigian, 1988, 2003a; Bedigian et al., 1985). Subsequently, it spreads to Africa, southwest Asia and East Asia.

Sesame is one of the most important oilseed crops in Sudan, both for local consumption and for export (Ahmed, 2008). It is widely grown under rain-fed conditions; in terms of land area, sesame ranks third after sorghum and millet. The most recent data available indicate that world sesame production was about 3.5 metric tons (MT) produced on 7.5 million ha. Highest producers are India (666,000 MT), Myanmar (620,000 MT), China (586,408 MT) and Sudan (350,000 MT) covering about 61.7% of the total world production (FAOSTAT 2009).

Many authors such as Vavilov (1949), Kumar et al. (1967), Muhammad et al. (1970), Weiss (1971), Osman and Khidir (1974), Bedigian et al. (1986) and Parameshwarappa et al. (2009) have reported a wide range of variability in most characters of the crop including seed yield and its components and other morphological traits namely: days to 50% flowering, days

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to maturity, plant height, number of branches per plant and height to first branch. Sverup et al. (1993) and Ali et al. (2003) reported high heritability estimates (>80%) for days to 50% flowering, days to maturity and 1000-seed weight. High heritability coupled with high genetic advance was given by height to first capsule. Gangadhara (2005) reported high heritability and high genetic advance for plant height, number of capsules per plant and 1000-seed weight which indicate the additive gene action, whereas high heritability and low genetic advance were recorded for days to 50% flowering, days to maturity, number of branches per plant and seed yield per plant which indicate the importance of non-additive gene action. Akpanlwo et al. (2009) reported that all characters studied had high heritability except capsule length.

Seed yield is a complex trait, polygenic and highly influenced by environmental conditions. A successful breeding programme depends upon the genetic variability present among the different genotypes. Phenotypic selection of parents for hybrids based only on their performance alone may not always be available procedure since phenotypically superior genotypes may yield inferior hybrids and/or poor recombinants in the segregating generations. It is therefore essential that parents are selected on the basis of their genetic worth, that is, heritability along with genetic advance are both important for selection. Khidir (1997) summarized one of the major problems facing sesame production in the Sudan to be: growing of poor and inferior genotypes with low yield and poor quality. To overcome the problems of low productivity of sesame, there must be a sound procedure for selection of high yielding varieties adapted to local environment. Therefore, the objectives of the current study are to estimate the phenotypic and the genotypic coefficients of variation, heritability in broad sense, genetic advance and genetic advance as percentage of the mean for yield, yield components and other morphological traits in seven sesame genotypes under rain-fed conditions.

MATERIALS AND METHODS

Location

Gedarif State is located in the eastern part of the Sudan Latitude 14° 1' 20''N, Longitude 35° 21' 45''E, elevation 592 m above the sea level. The soil is classified as Vertisol characterized by dark heavy cracking clay (75%) with low organic matter and low nitrogen contents (Blokhuis, 1993). The climate is semi-arid, rainfall is 300-500 mm in the North and 600-900 mm per year in the South. Mean temperature was 20°C in winter and 40°C in summer.

Experimental procedures and treatments

A field experiment was conducted for two consecutive rainy seasons: 2009 and 2010, at Sesame Research Center Farm, Gedarif, Sudan. In each season, a randomized complete block design with four replications was used for laying out the field experiment. Each block was divided into 7 plots, to which the genotypes were assigned randomly. The plot size was 2.4 × 5 m. Each genotype was represented by four rows, each five meters long and 0.6 m apart. Seven sesame genotypes from Sesame Research Center were used (Table 1). The seeds were sown in furrow along the row manually. Sowing date was on 18 July 2009 for the first season and on 14 July 2010 for the second season. The plants were trimmed to 24 plants/m^2 three weeks after sowing. The experimental area was kept free of weeds in both seasons. No pest's infestation or plant diseases were observed. Nitrogen fertilizer in the form of urea was applied at a rate of 80 kg/ha.

Data were recorded on the following phenotypic parameters: days to 50% flowering (DTFPF), days to maturity (DTM), plant height (cm) (PHT), number of capsules/plant (NCPP), seed yield/plant (g) (SYPP) and seed yield (kg/ha) (SYkg/Ha).

Analysis of variance was carried out for the data in each season and then combined over the two seasons to test for significant differences among the seven genotypes, according to the standard statistical procedure described by Gomez and Gomez (1984). The phenotypic and genotypic variances and their coefficients of variation, heritability in broad sense and the genetic advance for each character were estimated by the formula suggested by Singh and Chaudary (1985) as follows:

Phenotypic variance $(\sigma^2 ph) = \frac{M_2}{r} = \frac{\sigma^2 e + r\sigma^2 g}{r}$

Genotypic variance $(\sigma^2 g) = \frac{M_2 - M_3}{r} = \frac{(\sigma^2 e + r\sigma^2 g) - \sigma^2 e}{r}$

Where:

$\sigma^2 ph$ = phenotypic variance;

$\sigma^2 g$ = genotypic variance;

$\sigma^2 e$ = error variance; and

r = number of replications.

Phenotypic coefficient of variation (P.C.V) % = $\frac{\sqrt{\sigma^2 ph}}{\bar{\bar{x}}} \times 100$

Genotypic coefficient of variation (G.C.V) % = $\frac{\sqrt{\sigma^2 g}}{\bar{\bar{x}}} \times 100$

Heritability (h%) = $\frac{\sigma^2 g}{\sigma^2 ph} \times 100$ = $\frac{M_2 - M_3}{M_2} \times 100$

Table 1. Designation, name, pedigree and description for seven sesame genotypes used in the experiments.

S/N	Designation	Name	Pedigree	Description
1	A/1/9	Ziraa-9	Commercial variety developed by pure line selection method from local landrace material	It is characterized by profuse branching, late flowering and maturity and white small seeds. Stable yield over a wide set of environment (Osman, 1985).
2	K2	Kenana-2	A selection from an introduced material (30-15) from Pork. Faso.	A white seeded variety, short to medium duration (Ahmed, 2008)
3	(UCR770192)	Khidir	A selection from an introduced material	White seeded variety, short to medium duration (Ahmed, 2008).
4	K4	Promo	Variety selected from introduced materials of temperate origin (Greece)	High branching, medium duration, even maturity and delayed shattering (Ahmed et al., 1997; Ahmed, 2008).
5		Um Shagara	selected from segregated material of crosses between introduced and local cultivars the original seed stock of the introduced parent was from IDRC project	It is vigorous during the vegetative growth of dark green color, highly branching, medium duration to maturity, even maturity. Seeds are white and large (Ahmed et al., 2003).
6		Gedarif-1	A selection from segregating materials of crosses between temperate and tropical cultivars (UCR materials).	Characterized with non-branching habit, medium - late duration to flowering and good vigorous habit of growth (Ahmed et al., 2003).
7	SPS2003T10		Single pant selection in 2003 and it is under improvement.	Non-branched habit, three capsules per leaf axial and even early maturity. Seeds are white and large (Ali and Ahmed, 2004).

The genetic advance (GA) = $\dfrac{\sigma^2 g}{\sigma^2 ph} \times k\sigma p = \dfrac{\sigma^2 g}{\sigma ph} \times k$

Genetic advance as percentage of the mean (GA %) = $\dfrac{k\sigma^2 g}{\sigma ph} \times \dfrac{100}{\bar{x}}$

Where:

σph = phenotypic standard deviation;

k = selection differential which has the value of 2.06 at 5% selection intensity.

$\bar{x}$ = grand mean of the character.

RESULTS

The individual analysis of variance revealed significant differences for all characters in each season among the genotypes (Table 2). The earliest genotype combined over the two seasons was SPS2003T10 (77.80 days), whereas the latest one was Gedarif-1 (87.10 days). The tallest genotype (122.50 cm) was Gedaref-1 whereas the shortest one (70.00 cm) was SPS2003T10. The highest number of capsules per plant (49.30) was recorded for Gedaref-1 whereas the lowest number (3.98) was scored for SPS2003T10. The highest yielder genotype was Gedrif- 1 (591.00 kg/ha), whereas the lowest one was Ziraa-9 (361.00 kg/ha) (Table 3). Gedaref-1 out yielded the overall mean yield by 28.43% in the first season and by 23.88% in the second season. The variation in the phenotypic variances and the environmental variances in both season for most of the characters were quite evident. For example, the days to 50% flowering scored σ2ph, σ^2g and σ^2e variances of 9.82, 9.49 and 033 in the first season and 11.87, 11.67 and 0.11 in the second season, respectively, whereas, seed yield /plant recorded

Table 2. Mean square of analysis of variance for six characters of seven sesame genotypes evaluated at Sesame Research Center for two seasons (2009-2010).

Character	Season 2009		Season 2010	
	Genotypes	Error	Genotypes	Error
	df = 6	df = 18	df = 6	df = 18
Days to 50% flowering	39.28***	1.32	47.16***	0.47
Days to maturity	51.65***	1.45	37.83***	0.50
Plant height (cm)	986.98***	32.39	1454.31**	70.47
Number of capsules/plant	186.17*	55.34	387.16**	81.89
Seed yield/plant (g)	6.02**	1.01	5.71*	1.76
Seed yield (kg/ha)	40368.57**	7947.11	46518.31*	16083.48

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Table 3. Mean performance of seven sesame genotypes grown at Gedarif Sesame Research Centre (data combined over two seasons, 2009 and 2010).

Genotype	DTFPF	DTM	PHT	NCPP	SYPP	SYKg/H
Ziraa-9	44.60^{A}	85.60^{B}	115.00^{B}	40.60^{AB}	5.30^{B}	361.00^{C}
Kenana-2	36.90^{C}	81.80^{C}	105.70^{CD}	4O.60^{AB}	5.74^{B}	534.00^{AB}
Khidir	36.90^{C}	82.50^{C}	110.20^{BC}	36.30^{BC}	5.46^{B}	545.00^{AB}
Promo	37.50^{C}	82.60^{C}	95.80^{E}	31.10^{BC}	5.12^{BC}	441.00^{BC}
Um shagara	37.60^{C}	80.00^{D}	101.50^{DE}	38.80^{AB}	5.83^{B}	454.00^{BC}
Gedarif-1	41.40^{B}	87.10^{A}	122.50^{A}	49.30^{A}	7.34^{A}	591.00^{A}
SPS2003T10	35.10^{D}	77.80^{E}	70.00^{F}	26.40^{C}	3.98^{C}	394.00^{C}
C.V%	1.85	0.71	4.65	18.41	14.72	14.28
Overall mean	38.56	82.49	102.95	37.57	5.53	474.39

Means within the column sharing similar letter(s) are not significantly different at a probability level of 0.05 according to Duncan's Multiple Range Test (DMRT).

Table 4. Phenotypic ($\sigma^2 ph$), genotypic ($\sigma^2 g$) and environmental ($\sigma^2 e$) variances for the six characters of seven sesame genotypes evaluated at Sesame Research Center for two rainy seasons (2009 and 2010).

Character	Season 2009			Season 2010		
	$\sigma^2 ph$	$\sigma^2 g$	$\sigma^2 e$	$\sigma^2 ph$	$\sigma^2 g$	$\sigma^2 e$
Days to 50% flowering	9.82	9.49	0.33	11.79	11.67	0.12
Days to maturity	12.91	12.55	0.36	9.46	9.33	0.13
Plant height (cm)	246.74	238.65	8.10	363.58	345.96	17.62
Number of capsules/plant	46.54	32.71	13.83	96.79	76.32	20.47
Seed yield/plant (g)	1.51	1.25	0.25	1.43	0.99	0.44
Seed yield (kg/ha)	10092.14	8105.37	1986.77	11629.58	7608.71	4020.87

values of 1.50, 1.25 and 0.25 for the three variances, in the first season and 1.43, 0.99 and 0.44 in the second season, respectively (Table 4). The highest GCV values were recorded for the seed yield/plant in the first season (21.80) and for the number of capsules/plant in the second season (22.72), whereas the lowest values were scored for the number of days to maturity in both seasons (4.46 and 3.57). In both seasons, high heritability estimates (> 95%) with low genetic advance were observed for the days to 50% flowering, days to maturity and plant height, whereas moderate to low estimate of heritability (83.17 to 65.43%) coupled with medium to

Table 5. The phenotypic (PCV%), genotypic (GCV%), coefficients of variation, heritability (H%) estimates, genetic advance (GA) and genetic advance as percentage of the mean (GA%) in six characters of seven sesame genotypes evaluated at Sesame Research Center for two seasons (2009 and 2010).

Character	Season 2009					Season 2010				
	PCV%	GCV%	H%	GA	GA%	PCV%	GCV%	H%	GA	GA%
Days to 50% flowering	8.64	8.50	96.64	6.24	17.21	8.40	8.35	99.00	7.00	17.12
Days to maturity	4.52	4.46	97.19	7.20	9.06	3.60	3.57	98.68	6.25	7.31
Plant height (cm)	15.26	15.01	96.72	31.30	30.41	18.55	18.10	95.16	37.38	36.35
Number of capsules/plant	18.64	15.63	70.28	9.88	26.99	25.59	22.72	78.85	15.98	41.56
Seed yield/plant (g)	23.91	21.80	83.17	2.10	40.96	20.38	16.95	69.16	1.70	29.04
Seed yield (kg/ha)	20.21	18.12	80.31	166.21	33.45	24.14	19.52	65.43	145.34	32.53

high gain from selection were recorded for number of capsules/plant, seed yield/plant and seed yield/ha (Table 5).

DISCUSSION

All characters in both seasons revealed high significant differences among the studied genotypes. This indicates the presence of sufficient variability among the evaluated genotypes for the characters under consideration. This result was inconformity with the results reported by many authors Vavilov (1949), Kumar et al. (1967), Muhammad et al. (1970), Weiss (1971), Osman and Khidir (1974), Bedigian et al. (1986), and Parameshwarappa et al. (2009).

The variations among the genotypes were mostly due to genetics factors rather than environmental ones, as indicated by higher genetic variances compared to the environmental ones for the days to 50% flowering, days to maturity and the plant height which indicate that these traits were controlled by few genes and are less influenced by the environment and simple in nature of their inheritance. The high GCV recorded by the above mentioned traits alone is not sufficient for the determination of the extent of the 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. In this study, in both seasons, the high estimates of heritability with low genetic advance for the days to 50% flowering, days to maturity and plant height, render them unsuitable for improvement through conventional selection and confirm that high heritability alone does not signify an increased genetic advance (Govindarasu et al., 1990). On the other hand, moderate to low estimates of heritability coupled with medium to high genetic gain for number of capsules/plant, seed yield/plant and seed yield /ha show that genotypic variance for these characters is probably owing to high additive gene effect. Thus, the yield and its components are controlled by many genes, complex in nature of inheritance and much influenced by environmental conditions. Therefore direct selection for yield and its components will not be effective and consequently there is a need for methods other than simple selection to improve yield in sesame. Similar findings were reported by Ramanathan (2004) in sesame, and Gill et al. (1997) and Mohamed and Abdella (2007) in sunflower.

Conclusion

From the results of this study, the following conclusion could be drawn. Sufficient genetic variability for yield and its components existed among the genotypes under study. High to moderate heritability accompanied with low genetic advance were recorded for days to 50% flowering, days to maturity and plant height which indicate their dominant and epistatic nature of inheritance (non-additive gene action), whereas low heritability with high genetic advance were observed for the yield and its components which indicate the additive nature of inheritance.

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