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Production potential for sesame in the forest-savanna transition zone of south-west Nigeria

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Abstract

The performance of fourteen sesame (*Sesamum indicum* L.) cultivars was evaluated at the Teaching and Research farm of University of Agriculture, Abeokuta (7° 15' N, 3° 25' E) in the forest – savanna transition zone of south west Nigeria during the late cropping seasons of 1999 and 2000. Data were collected on phenology, growth characteristics, grain yields and yield components of sesame. The results revealed that the sesame varieties flowered, produced capsules and matured at 49-60, 58-74 and 96-106 days after planting (DAP), respectively. Number of branches and capsules per plant ranged between 2-4 and 13-37, respectively. The sesame entries recorded grain yields that ranged between 374.0 (Domu) and 899.46 kg ha^{-1} (530-3). All the varieties except Yandev 55 (a local variety used as check in the study) (448.94 kg ha^{-1}) and Domu (374.94 kg ha^{-1}) produced grain yields higher than the current Nigerian average yield of 487 kg ha^{-1}. Grain yield was highly associated ($P<0.01$) with number of nodes and capsules per plant. The overall performance of these varieties in this study, is similar to results reported for sesame generally in the southern Guinea savanna region of Nigeria. Consequently, this confirmed the suitability of the forest – savanna transition zone for sesame production. The distribution of rainfall and temperature during the two late cropping seasons and their relevance to the productivity of the sesame varieties is discussed.

Key words: Agronomic performance, productivity, *Sesamum indicum*, yield

Introduction

Sesame or beniseed (*Sesamum indicum* L.) is one of the oldest cultivated plants in the world and it probably originated from Ethiopia. Sesame gained prominence in Nigerian agriculture in the mid sixties when Mokwa experimental station of The Institute of Agricultural Research located in the southern Guinea savanna region was chosen as the Centre for sesame research in Nigeria (Voh, 1998). Consequently, most of the pioneer research activities were carried out at this station (van Rheenen, 1967, 1970, 1973). The crop which is now well established in the African savanna is cultivated mainly for its seeds which contains approximately 50% oil and 25% protein (Oplinger *et al.*, 1990). The oil of sesame is free from undesirable nutritional or flavour components and is very stable because it contains natural antioxidants such as *sesamin* and *sesamolin* which prevent ageing and malfunctioning of liver. The oil is also used in the manufacture of paints, soaps, perfumes, pharmaceuticals and insecticides. Sesame meal (residue after oil extraction) is an excellent high protein (34-50%) feed supplement for livetock (Oplinger *et al.*, 1990). The largest buyer of Nigerian sesame is Japan where sesame seeds are used in baking, candy making, other food industries and for industrial purposes (Coote, 1998). The local people in the sesame growing regions of Nigeria also eat sesame seeds fried, roasted or pounded and mixed with sugar (Voh, 1998).

According to FAO (2000), world projected production in 2001 was 2.84 million tons on 7.40 million hectares. The estimated total production in Africa was put at 741,956 tons with Sudan, Uganda and

Nigeria accounting for 40, 13 and 9.3%, respectively. Harvested area under sesame in Nigeria increased by 37.2% between 1990 and 2001 (FAO,2000). The average yields of sesame in the world (263 kg ha^{-1}) and Africa (383 kg ha^{-1}) are still very low compared to yields of up to 1.2, 1.1 and 0.7 t ha^{-1} in Egypt, Honduras and Ethiopia, respectively (FAO,2000). The earlier reported low yield of 300 kg ha^{-1} of sesame in Nigeria by Philip (1977) has increased from 400 kg ha^{-1} in 1990 to 457 kg ha^{-1} in 2001(FAO,2000). This increase could easily be attributed to cultivation of improved local cultivars under improved cultural practices.

Sesame is adapted to tropical and temperate conditions. In West Africa it is cultivated in areas where annual rainfall ranges from 500mm in the Sudan savanna to 1,100-1,500mm in the southern Guinea and derived savanna. However, the traditional sesame growing regions in Nigeria fall within latitudes 6° and 10° N (Agboola, 1979) and these regions receive a little below 1,000mm of rainfall. In a three year study conducted on sesame in the forest region where rainfall is usually above 1000mm per annum, an encouraging average yield of 693 kg ha^{-1} was recorded (Ogunremi, 1985). This suggests that other regions bordering the traditional growing areas of sesame such as the forest-savanna transition zone with annual rainfall above 1000mm could also be exploited for sesame cultivation.

Despite the increasing demand for Nigerian sesame seeds in the world market, especially Japan, there are still no large scale commercial growers of this crop. The two improved released varieties (E8 and Pb Til) alongside the adapted local varieties like Yandev 55 and Okenne local are still cultivated within the traditional growing regions. In order to meet the increasing local and international demand of Nigerian sesame seeds which is a highly favoured source of foreign exchange income, this study was aimed at evaluating the performance of some sesame improved and promising cultivars in other potential areas of cultivation such as the forest-savanna transition zone of south west, Nigeria.

Materials and methods

The study area

Figure 1 shows the location of the study area and the vegetation of Ogun State of Nigeria. The State covers an area of about 14,409,260 sq. km with a population of about 2.8 million people (OGADEP, 1999). The vegetation of the state ranges between the derived savanna (forest-savanna transition) in the north to deltaic swamp complex in the south. The study area is located in the forest-savanna transition zone where the original vegetation had been altered by bush burning and continous cultivation. Consequently, grasses (*Panicum maximum, Imperata cylindrica)* and some trees (*Afselia africana, Daniellia oliveri)* and shrubs (*Chromolaena odorata*), which are fire resistant now remain in the area. The major arable crops in the area include cassava *(Manihot esculentum)*, maize *(Zea mays)*, yam *(Docus carota)*, cocoyam *(Docus* sp.*)*, rice *(Oryza sativa)*, vegetables, pepper, okra, *Amaranthus* species, *Celosia* species and legumes (cowpea *(Vigna unguiculata)* and groundnut *(Arachis hypogea)* (Tayo *et al.*, 1992). The experimental site was located at the Teaching and Research farm of University of Agriculture, Abeokuta (7°15'N, 3°25'E). The soil of the site was oxic paleudulf (Adetunji, 1991) and it had a pH of 5.6, 0.87% organic carbon, 0.05% total N, 2.23 mq kg^{-1} available P (Bray's P1) and 1.3 mmol(+) kg^{-1} exchangeable K. Traditionally, rainfall distribution in this region is usually bimodal with peaks usually in July and September and a short dry spell in August often referred to as *August Break.* However, this trend was not observed during the period of experimentation in both years. Figure 2 shows the mean monthly rainfall and temperature for 1999, 2000 and fifteen year mean of 1982 - 1996 during the late cropping season. The experimental fields were previously cropped to maize in both years.

Experimental design and treatments

The experimental design was randomised complete block design with three replicates. Fourteen varieties of sesame were collected from National Cereals Research Institute, Badeggi, Niger State which has the national mandate for research (genetic improvement) and development of sesame production in Nigeria. The varieties were: E8, Yandev 55, Goza, Type 4, 73A-11, 73A-79, 530-6-1,69B-88Z, Domu, 73A-97, C-K2, 73A-94, 530-3 and PB Til. E8 (an improved and released variety) and Yandev 55 (an adapted local variety) were used as control checks in the study. Seeds were planted at a spacing of 60 x 5cm on 7th and 31st July, 1999 and 2000, respectively. The seedlings were thinned

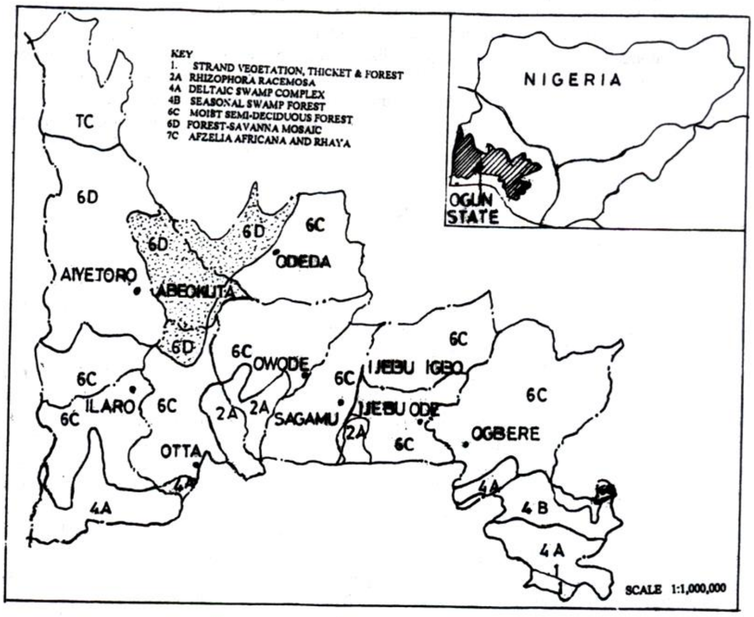

Figure 1. Vegetation map of Ogun State showing the study location. Source: Tayo et al., 1992.

to one plant per stand at three weeks after planting (WAP). While manual weeding of plots was done at 5 and 9 WAP in both years. Fertiliser was applied at the rate of 60 kg N ha^{-1}, 30 kg $^{-1}$ P_2O_5 and 50 kg K_2O ha^{-1} at 6WAP (Olowe and Busari, 2000).

Observations and staistical analysis

Data were collected on phenology (number of days to flowering, capsule formation and maturity), growth parameters (height at flowering, maturity, height of lowest capsule and number of nodes per plant), yield components (number of branches and capsules per plant, weight of capsules and seeds per plant, average plant weight, harvest index, seed production efficiency, and 1000 seed weight) and grain yields. The data obtained were subjected to combined analysis of variance. Simple correlation analysis was also carried out to determine the level of relationship between eight yield parameters and grain yield. Means of significant treatments were separated using the Duncan's Multiple Range Test (Steel *et al.*, 1997).

Results and discussion

Rainfall and temperature distribution

Figure 2 shows rainfall and temperature distribution for both 1999 and 2000 compared to the fifteen year mean (1983-1994). The total amount of rainfall during the period of experimentation (June – November) in 1999, 2000 and fifteen year mean was 566.8, 917.5 mm and 802.3 mm, respectively. These values were 30 and 14% lower and higher than the fifteen year mean for the study area, respectively. The late cropping season of year 2000 was wetter than that of 1999. Consequently, the period could be described as wet (i.e., irrigation not essential) because the rainfall bars cross the mean temperature curve particularly in July, August and September which happened to be the period of active vegetative and reproductive phases of sesame. However, in 1999 since the rainfall bars did not cross the mean temperature curves throughout the late cropping season except in August, the season

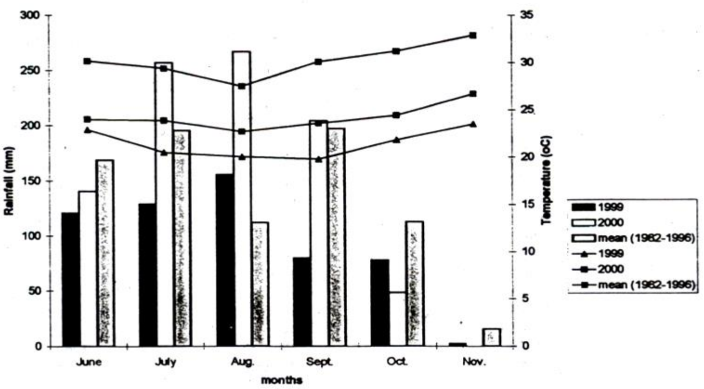

Figure 2. Monthly rainfall and mean monthly temperature for 1999, 2000 and mean for 1982 - 1996 during the late cropping season.

could be said to be dry (i.e., irrigation essential) according to Olasantan (1996). The mean monthly temperature during the late cropping season averaged 21.4°, 24.2° and 30.2°C in 1999, 2000 and for the fifteen year mean, respectively. However, the fifteen year monthly mean temperature was markedly higher than the mean temperature of 1999 and 2000 throughout the late cropping season.

Phenological observations

Significant differences ($P<0.05$) were recorded amongst the fourteen entries for number of days to flowering, capsule formation and maturity (Table 1). Number of days to flowering and capsule formation ranged between 49 – 60 and 58 – 74 DAP among the entries, respectively. Type 4 attained these two stages earlier than all the other entries. The observed range of 49 – 60 DAP to flowering is very similar to the reported ranges of 37 – 58 (Adeyemo and Ojo, 1993) and 42 – 67 DAP (Iwo *et al.*, 1998) from the middle belt zone of Nigeria. Number of days to maturity ranged between 96 DAP (Domu) to 106 DAP (73A-94). Based on these findings, the fourteen entries could be described as early maturing which is a desirable trait for crops growing in regions with limited rainfall particularly in the late season.

Growth parameters

All the varieties exhibited significant ($P<0.05$) height characteristics (Table 2). The two control checks (E8 and Yandev 55) recorded height at flowering and maturity that were comparable to the values recorded by other varieties; although, 530-3 (147.12 cm) was significantly ($P<0.05$) taller than E8 (126.27 cm) at maturity. The range of height of 115.18 – 147.12 cm at maturity is very close to 125.0 – 187.0 and 119.9 – 148.3 cm, reported for sesame in the southern Guinea savanna zone of Nigeria by Adeyemo and Ojo (1993) and Busari and Ajewole (1993), respectively. The height of the lowest capsule ranged between 56.77 (Yandev 55) – 76.75 cm (530-6-1). This trait is more of a varietal characteristic (Weiss, 1984) and it has implication if sesame is to be harvested mechanically because it will determine the height at which the cutter bar must be adjusted to minimize field loss during mechanical harvesting. Variety 530-3 produced the highest number of nodes per plant (104) and 73A-97 the lowest (30). This trait is also a varietal characteristic (Weiss, 1984).

Table 1. Number of days to flowering, capsule formation and maturity of fourteen sesame varieties

Varieties	Number of days to		
	Flowering	Capsule formation	Maturity
E 8	54def	67cd	103bc
Yandev 55	56bcde	69bcd	100de
Goza	57abcd	71ab	104bc
Type 4	49h	58f	100de
73A-11	53efg	71abc	105abc
73A-79	59ab	73ab	103bc
530-6-1	50gh	62ef	99e
69B-88Z	60a	72ab	105abc
Domu	52fgh	66de	96f
73A-97	55cdef	74a	102cd
C-K2	57abcd	71abc	103bc
73A-94	58abc	72ab	106a
530-3	59ab	73a	102cd

Means along columns with a common letter are not significantly different from each other according to Duncan's Multiple Range Test (DMRT).

Grain yield and yield components

Results of grain yield and some yield components of the fourteen sesame varieties are presented in Table 3. They all produced 2 – 4 branches per plant. This confirmed the findings of Iwo *et al.* (1998) that sesame rarely produce more than four branches per plant. The number and weight of capsules per plant and average plant weight produced by E8 and Yandev 55 were similar to the observations recorded from most of the other entries except 73A-97 which had 13 capsules per plant (significant $P<0.05$). However, the number of capsules per plant 13-17 (the lowest) produced by these varieties in the forest-savanna transition location is relatively lower than those (43 - 52) reported for sesame in the southern Guinea savanna environment by Adeyemo and Ogunwolu (1996). Variety C-K 2 recorded the highest weight of seeds per plant (4.27g) while the values for other entries were similar. These values were also slightly lower to the 5.3 – 5.4 gm plant^{-1} reported by Adeyemo and Ogunwolu (1996).

Harvest index (HI) describes the ability of a plant to partition manufactured assimilate into the seeds and is a ratio of weight of seeds to weight of above ground plant part expressed in percentage. Yandev 55 which is a locally adapted variety recorded the lowest value of 6.91% compared with 19.22% by Goza. On the average, all the entries that recorded HI above 10% produced comparable grain yields. Seed production efficiency (SPE) is the ratio of seed weight to capsule weight expressed in percentage and was used to measure the ability of sesame to produce seeds (Ogunremi, 1985). The values of this parameter by the entries ranged between 35.20 to 59.10% and were higher than 29.4% (Yandev 55) and 37.4% (65A-36) reported by Ogunremi (1985).

The fourteen varieties in this study produced grain yields that ranged from 374.0 (Domu) to 899.46 kg ha^{-1} (530-3). When compared to the current world (263 kg ha^{-1}), Africa (383 kg ha^{-1}) and Nigeria (457 kg ha^{-1}) averages, only Domu and Yandev recorded lower grain yields. These values are at par with grain yields reported by Iwo *et al.* (1998) for sesame in the middle belt zone of Nigeria. To date, only E 8, Yandev 55 and PB Til have been released to farmers. Variety E 8 which is an improved variety and a check in this study produced the fifth highest yield of 749.9 kg ha^{-1} which was not significantly different from the four top yielders. Yandev 55 which is a local adapted variety and the second check produced an average yield of 448.94 kg ha^{-1} which is slightly lower than the current Nigerian average of 487 kg ha^{-1}. The fourteen sesame varieties recorded higher yields in 2000 than 1999. The top six

Table 2. Some Height Characteristics of Fourteen sesame varieties.

Varieties	Plant height (cm) at		Height (cm) of lowest capsule	Numbe of nodes per plant
	flowering	maturity		
E 8	58.46abc	126.27bc	69.13abc	92ab
Yandev 55	61.42ab	132.37abc	76.75a	73abc
Goza	55.63abc	141.75ab	71.22abc	74abc
Type 4	61.15ab	135.03abc	59.05c	91ab
73A-11	62.92ab	132.20abc	76.10a	63abc
73A-79	52.52bc	131.50abc	68.40abc	66abc
530-6-1	56.95abc	134.00abc	56.77c	91ab
69B-88Z	49.63c	134.27abc	74.72ab	93ab
Domu	53.54bc	124.90bc	61.30bc	56bc
73A-97	53.59bc	115.18c	59.20c	30c
C-K2	58.43abc	131.07abc	63.93abc	62abc
73A-94	54.00bc	128.53abc	74.23ab	57bc
530-3	58.37abc	147.12a	76.58a	104a

Means along columns with a common letter are not significantly different from each other according to Duncan's Multiple Range Test (DMRT).

Table 3. Grain yield and some yield components of fourteen sesame varieties.

Varieties	Number of		Average plant weight (g)	Weight (g) of		Harvest index (%)	SPE (%)	1000 seed weight (g)	Grain yield (kg ha⁻¹)
	branches per plant	capsules per plant		capsules per plant	seeds per plant				
E 8	3abc	32abc	29.07abc	7.68abc	2.10b	16.83ab	52.05ab	2.97ab	749.90abc
Yandev 55	3abc	25abcd	33.63a	5.47ab	2.16b	6.91c	36.85de	2.45de	448.94cd
Goza	3abc	31abc	27.82abcd	9.38a	2.30b	19.22a	55.82ab	2.75bc	580.37abcd
Type 4	2cd	30abc	30.58abc	8.03ab	1.87b	15.80ab	52.68abc	3.03ab	811.86ab
73A-11	2cd	23abcd	22.78bcd	4.64bc	2.45b	12.68abc	59.10a	3.00ab	564.96bcd
73A-79	2cd	22bcd	22.35bcd	6.18abc	2.40b	15.57ab	49.90abcd	2.95ab	653.51abcd
530-6-1	2cd	27abc	33.15a	7.22abc	2.25b	14.97abc	55.50ab	3.11a	893.07a
69B-88Z	4a	29abc	25.9abcd	8.28ab	2.25b	13.52abc	40.50cde	2.82bc	677.32abcd
Domu	2cd	19cd	22.62bcd	5.12abc	1.67b	12.55abc	47.07abcde	2.60cde	374.31d
73A-97	2cd	13d	19.02d	3.45c	2.38b	10.27bc	49.60abcd	3.23a	555.67bcd
C-K2	3abc	28abc	21.09cd	7.62abc	4.27a	13.58ab	35.20e	2.43e	555.53bcd
73A-94	3abc	23abc	21.92bcd	8.25ab	2.83b	15.28ab	42.32bcde	2.67cd	523.8484
530-3	3abc	37a	26.53abcd	9048a	2.3b	17.73ab	47.02abcde	2.98ab	899.46a

Means along columns with a common letter are not significantly different from each other according to Duncan's Multiple range Test (DMRT).
SPE – Seed Production Efficiency.

yielders (530-3, 530-6-1, PB Til, Type 4, E 8 and 69B-88Z) were the same in both years (Table 4). The total amount of rainfall and mean monthly temperatures were 62% higher and 1.2 - 3.2°C warmer during the late cropping season of 2000 than 1999. Furthermore, the more favourable rainfall distribution in 2000 and the slightly warmer temperature experienced in October and November apparently enhanced the performance of sesame in 2000 over 1999 (Fig. 2).

Relationship between grain yield and eight yield components

The correlation coefficients (Table 5) revealed that grain yield and plant height at maturity, number of nodes per plant, number and weight of capsules per plant and weight of seeds per plant were significantly and positively related suggesting that these traits contributed to the grain yield of sesame. Similarly, weight of seeds, number and weight of capsules per plant, number of nodes per plant and height at maturity were highly positively associated (significant at $P<0.01$) with each other. Harvest index was highly significantly positively associated with weight of seeds ($r=0.85$) and capsules

Table 4 Grain yield of fourteen sesame varieties.

Varieties	1999	2000	Mean
E 8	450.50bcd	1049.30ab	749.90abc
Yandev 55	260.30cd	635.5bc	448.94cd
Goza	156.10d	1004.64abc	580.37abcd
Type 4	569.10abc	1054.59ab	811.86ab
73A – 11	277.41cd	855.87abc	564.96bcd
73A – 79	341.13bcd	989.89abc	653.51abcd
530-6-1	628.57ab	1157.60ab	893.07a
69B-88Z	346.97bcd	1007.67abc	677.32abcd
Domu	283.87cd	464.75c	374.31d
73A-97	153.90d	955.77abc	555.67bcd
C-K2	290.93cd	820.12abc	555.53bcd
73A-94	302.00cd	745.67bc	523.84bcd
530-3	733.49a	1065.41ab	899.46a
PB Til	436.37bcd	1347.17a	891.77a

Means along columns with a common letter are not significantly different from each other according to Duncan's Multiple Range Test (DMRT).

Table 5. Correlation coefficients among nine agronomic characters measured during two years for fourteen sesame varieties.

Traits	Height at flowering	Height at maturity	Number of capsules per plant	Number of nodes per plant	Weight of capsules per plant	Weight of seeds per plant	1000 seed weight	Harvest index
Grain yield	0.32	0.53*	0.67**	0.78**	0.56**	0.57**	0.50	0.45
Height at flowering	-	0.26	0.41	0.34	0.13	0.10	-0.03	-0.21
Height at maturity		-	0.84**	0.75**	0.76**	0.75**	-0.15	0.50
Number of capsules/plant			-	0.90**	0.85**	0.80**	-0.13	0.51
Number of nodes/plant				-	0.73**	0.68**	0.06	0.40
Weight of capsules/plant					-	-	-0.18	0.70**
Weight of seeds/plant						-	0.02	0.85**
1000 seed weight							-	0.27
Harvest index								-

* and ** significant at 5 and 1%, respectively.

(r=0.70) per plant. Ogunremi and Ogunbodede (1986) also reported significant positive association of number and weight of capsules per plant, weight of seeds per plant and plant height at maturity with grain yield. They recommended that number of capsules per plant, weight of seeds per plant and plant height among other traits should be considered in selection for high yield capacity in sesame production. The encouraging average performance of these fourteen sesame varieties in a forest – savanna zone over two years confirms its suitability for the cultivation of sesame.

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