



EFFECT OF FERTILIZER APPLICATION ON SOIL PROPERTIES AND YIELD OF SESAME (*Sesamum indicum* L.) VARIETIES IN SOUTHERN GUINEA AND SUDAN SAVANNA AGRO-ECOLOGICAL ZONES OF NIGERIA

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ABSTRACT: Field experiments were carried out in 2018 and 2019 cropping seasons to determine the effect of fertilizer application on soil properties and yield of sesame varieties in Southern Guinea and Sudan Savanna Agro-ecological Zones of Nigeria. Treatments consisted of three varieties of sesame (Jigida, NCRIBEN-01M and NCRIBEN-032) and four levels of NPK 15:15:15 fertilizer (0, 50, 100 and 150 kg ha⁻¹). Treatments were laid out in a randomized complete block design (RCBD) and replicated thrice. Prior to planting, surface (0-15 cm) soil samples were collected from eight points and bulked; post-harvest composite soil samples were also collected on the basis of treatments. All soil samples were analyzed using standard analytical procedures. Data on yield parameters collected include number of capsules per plant, number of seeds per capsule, length of capsule (cm), 1000 capsule weight (g), 1000 seeds weight (g) and seed yield (t ha⁻¹). The crop data generated from the study were subjected to Analysis of Variance (ANOVA) using Genstat Release 10.3 DE after which significant means were separated using Least Significant Difference (LSD) at 5 % level of probability. Results indicated that the soils of both locations were inherently poor in essential plant nutrients. The improved varieties (NCRIBEN-01M and NCRIBEN-032) performed better than the local variety in terms of yields in both cropping seasons. Sesame yield increased with increase in fertilizer application rates up to 150 kg ha⁻¹. The effect of varieties on soil properties did not differ significantly however, the improved varieties left lower essential nutrients in soil when compared with the local variety. Fertilizer application at 150 kg ha⁻¹ favoured the retention of organic matter as well as other essential nutrient elements in soil. Location effect showed that the Potiskum soil had more nutrients than that of Makurdi. For sustainable sesame production and maintenance of soil fertility in both locations, application of 150 kg ha⁻¹ of NPK 15:15:15 to sesame fields is recommended.

KEYWORDS: Sesame Varieties, Fertilizer, Yield, Southern Guinea and Sudan Savanna, Nigeria



INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest and most important oil seed crops widely grown in tropical and sub-tropical regions around the world and is cultivated for its oil-rich seeds, which grow in pods (NCRI, 2002). Sesame is grown in more than seventy countries worldwide. According to USAID (2002), the United Republic of Tanzania, India, China, Sudan, Nigeria, Myanmar, Burkina Faso and Ethiopia are the greatest sesame producers, respectively covering 70.88 % of the world production. However, the production of sesame in the tropics has lagged behind other crops due to a lack of research, shortage of trained personnel, limited financial support and limited international cooperation. The crop is not dealt with by any of Consultative Group on International Agricultural Research (CGIAR) centers even when the crop has high agronomic importance as it adapts to harsh environments where other oil or food or export crops cannot tolerate (Biswas *et al.*, 2001 and Iwo *et al.*, 2002).

In most tropical countries, the mean yield of sesame is very low (Naturland, 2002) as a result of many production constraints hindering considerable yield improvement. Indeterminate flowering nature and shattering of capsules at maturity, insects, pests and diseases, heat and drought, among other things are the major factors for low yields of sesame (NCRI, 2002). The potential yield of sesame is still much higher than the actual yield, as much damage occurs by pests and diseases, insufficient weed control, to high levels of monocropping, lack of mechanization (amongst others causing seed shattering where not enough labour is available during harvest) and unrealized genetic potential. Potential yields are probably as high as 2000 kg ha⁻¹ (Adebawale *et al.*, 2010; Hansen, 2011). Eifediyi (2016) stated that other major constraints to sesame production in the tropics are poor road network, poor access to credit facilities, poor extension services, high cost of inorganic fertilizers and other farm inputs.

The importance of fertilizer as agricultural input cannot be over emphasized, particularly in Nigeria where the nutrient levels of the soils are low (Agbede, 2009; Eifediyi, 2016). Fertilizer has been used to improve the yield of sesame for many years especially in the savanna region of Nigeria, where it is a sine-qua-non in fertility management because of the inherently low organic matter content of the soils in the region (Ali *et al.*, 2006). Fertilizer effects on plant growth and yield depend on the crop grown and the environmental conditions that crop encounters. Responses of various crops, including sesame, soybeans, maize, groundnut, wheat and rice to fertilizer application have been studied in Nigeria (Eifediyi *et al.*, 2016 and Ojeniyi *et al.*, 2016) and found to improve crop productivity.

Survey reports by various researchers in the savanna areas revealed that the yield of the sesame crop is low, probably due to lack of improved varieties and poor cultural practices used by farmers. According to Eifediyi *et al.*, (2018), cultivating the crop early in the season predisposes it to vegetative growth and pest invasion. In addition, traditional sesame growers in the study areas rarely use fertilizers to increase the yield. Studies have shown that the crop performs well with the application of inorganic fertilizers (Ojeniyi *et al.*, 2016; Eifediyi *et al.*, 2018) and the use of improved varieties.

Therefore, for sustainable production of sesame, there is a need for adoption of appropriate fertilizer recommendation and improved varieties that would ensure optimum yield. The present study was undertaken to provide documented information on the response of sesame



varieties and soil properties to fertilizer application with a view to sustaining productivity through appropriate fertilizer application rates across the study agro-ecological zones.

MATERIALS AND METHODS

Experimental Site

Field experiments were conducted during 2018 and 2019 cropping seasons at the Teaching and Research Farms of the Federal University of Agriculture, Makurdi, Nigeria and Federal College of Education (Technical), Potiskum, Yobe State, Nigeria to determine the effect of fertilizer application on soil properties and yield of sesame varieties. The Makurdi location falls within the Southern Guinea Savanna Zone of Nigeria with mean rainfall of about 1,250 mm per annum and temperature of 25-30 °C. It is located between latitude 7° 41' N to 7° 42' N and longitude 8° 37' E to 8° 38' E. The Potiskum location falls within the Sudan Savanna Zone of Nigeria with mean rainfall of about 800 mm per annum and temperature of 39 – 42 °C. It is located between latitude 11° 42' N to 11° 43' N and longitude 11° 04' E to 11° 06' E (YSGN, 2008). The two vegetation zones in Yobe State are Sahel in the North and the Sudan Savanna in the Southern part of the state where Potiskum is located.

Treatments consisted of three varieties of sesame (Jigida, NCRIBEN-01M and NCRIBEN-032) and four levels of NPK 15:15:15 fertilizer (0, 50, 100 and 150 kg ha⁻¹). Treatments were laid out in a RCBD with sesame varieties occupying the main plots and fertilizer levels at sub plots and were replicated thrice. The experimental sites at both locations were cleared manually using cutlass and demarcated into experimental units. Thereafter, flat beds and ridges were made using a hoe. NCRIBEN-01M and NCRIBEN-032 (improved varieties) of sesame were sourced from National Cereals Research Institute, Badeggi-Niger State and Jigida (local variety) was sourced from the local farmers. The local variety served as a check at both locations for both cropping seasons.

Sesame seeds were sown at an inter and intra row spacing of 75 x 5 cm. Sesame seeds were drilled along the ridges (or straight lines on flat land) and thinned to have two plants per stand along the row two weeks after planting (WAP) to give a plant population of 133,333 plants ha⁻¹ (Jakusko and Usman, 2013). This permits maintenance of appropriate plant density and also alleviates the attendant problems associated with high-density planting.

Two hoe weeding at 3 and 9 weeks after planting (WAP) were done during the period of the experiments. Soil mounds were built around the plant stands at each weeding. The fertilizer application was done at 2 WAP by band placement in alternate rows at both locations for both cropping seasons. Crop harvested from the net plots were used for grain yield determination at both locations. Sesame crop was harvested when about 50 % of the capsules turned yellow in colour from green. Harvesting was not delayed in order to prevent seed loss through shattering. Harvesting was done by cutting the stems with sickles. Harvesting by pulling the plants from the root was avoided in order to prevent contamination of seeds with sand. After harvesting, the plants were tied with a rope into bundles and positioned in an erected form on tarpaulin for the capsules to be fully dried.



Soil Data Collection and Analysis

Prior to planting for both cropping seasons at both locations, surface (0-15 cm) soil samples were collected from eight points and bulked; post-harvest composite soil samples were also collected on the basis of treatments. The soil samples taken from each plot according to treatment were air dried, crushed and sieved using 2 mm sieve and analyzed using standard soil analytical procedures at the Departments of Soil Science, Federal University of Agriculture, Makurdi, Nigeria and University of Maiduguri, Borno State, Nigeria. Particle size distribution was determined by the Hydrometer method (Bouyocous, 1951). Soil pH was measured with the glass electrode pH meter in soil solution ratio 1: 2 in 0.01 M CaCl₂. Soil organic carbon (OC) was determined by the Walkey and Black method. Total N by the macro-Kjeldahl digestion method (Bremner and Mulraney, 1982), Available P was determined by Bray and Kurtz (1945) extraction method. Exchangeable cations were extracted using NH₄OAC solution, K and Na were read using flame photometer, while Ca and Mg was determined using the Atomic Absorption Spectrophotometer (AAS). Effective cation exchange capacity (ECEC) was established as the summation of the exchangeable cations (K, Na, Ca, Mg) and exchange acidity. **Crop Data Collection and Analysis**

Data were collected for the yield parameters of sesame for both cropping seasons at both locations as follows:-

The lengths of ten capsules from each net plot were measured from bottom of the sesame capsule to the capsule apex using a meter rule and the average value recorded. Five plants in the net plot were sampled, the number of capsules on each plant counted and average value determined and recorded. 1000 capsules were taken from ten sampled plants per plot and weighed also on a sensitive Mettler top-loading electronic balance (Model P. 1200), after which the mean weights were recorded. Ten dry capsules were sampled randomly from each net plot. They were split open and the number of seeds in each capsule counted and average values were recorded. A total of 1000 sesame seeds from each plot were counted and weighed on an electronic top-loading Mettler balance to obtain the weight of 1000 seeds. From the seed yield per plot, seed yield per hectare for each plot was computed by converting it into kilogram per hectare by extrapolation.

Data collected for the yield parameters of sesame for both cropping seasons were subjected to the Analysis of Variance (ANOVA) using Genstat Release 10.3 DE after which significant means were separated using Least Significant Difference (LSD) at 5 % level of probability.

RESULTS AND DISCUSSION

Physical and Chemical Properties of Soil of the Experimental Sites before Planting

Selected physical and chemical properties of soil of the experimental sites (Table 1) indicate that soils were sandy loam and sandy clay loam in texture for Makurdi and Potiskum sites respectively. This texture is ideal for sesame production as sesame require soils that are well drained for optimum growth and yield. The high sand content of the soils for both seasons respectively (71.8 and 67.10 %) was indicative of the low clay content which could be attributed to the soil separate sorting activities by organisms, clay eluviation, surface soil



erosion, parent material or a combination of these factors (Odunze *et al.*, 2006; Malgwi *et al.*, 2008).

The slightly acidic pH of the soils (6.08 – 6.96) also indicates that the soils are suitable for sesame production as this pH range is the optimum pH for most crops and microbial activities in soil. Bennet (2011) reported that Sesame is intolerant of very acidic or saline soils hence the pH obtained from these soils is ideal for optimum sesame production. Very low pH values have a drastic effect on growth, whereas some varieties can tolerate a pH value up to 8 (Naturland, 2002; Akinoso *et al.*, 2010).

The soils were low in essential plant nutrients and organic carbon (0.53 and 0.57 %) with the exception of sodium (0.24 and 0.20 cmol kg⁻¹) in Makurdi which was moderate when compared with soil fertility ratings by Esu (1991). The poor nutrient status of this soil is characteristic of many tropical soils where the slash and burn practice coupled with high insolation and rainfall prevent the build-up of organic matter which is the storehouse of most nutrients (Anjembe, 2004). This is in line with earlier observations by Aduayi *et al.* (2002) and Senjobi *et al.* (2013) who reported that Nigeria soils are deficient in most nutrients. Other factors responsible for the low nutrient status may include intensive and continuous cropping without corresponding fertilizer application, weathering, and erosion/leaching losses. The low Phosphorus content could be as a result of high P fixing capacity of most tropical soils (Ibrahim, 2017). The low nutrient status of the soil indicates a high probability of getting a response to the application of fertilizers when the soil is cultivated, otherwise partial or total crop failure is probable.

Main Effects of Varieties and Fertilizer Application on the Yield of Sesame

The main effects of the sesame varieties and fertilizer Application on the yield of sesame in the 2018 and 2019 cropping season are shown on Table 2. Results indicated that the varieties had significant differences on all the parameters measured with the exception of capsule length and number of seeds per capsules and weight of 1000 seeds. There were significant differences in the varieties with respect to some of the yield attributes such as number of capsules per plant, weight of 1000 capsules and 1000 seeds as well as grain yield as a result of the differences in the varieties and apart from the local variety (jigida), the other varieties have been bred for higher yield and other desirable qualities.

NCRIBEN-01M gave a yield of 0.54 t ha⁻¹ in Makurdi and NCRIBEN-032 gave a yield of 0.87 t ha⁻¹ in Potiskum in 2018. In 2019, the highest yields of 0.44 and 1.38 t ha⁻¹ in Makurdi and Potiskum respectively were obtained with NCRIBEN-032. Ridges produced higher yields followed by flat beds and then zero tillage in both locations. Ridges produced yields of 0.45 and 0.86 t ha⁻¹ in Makurdi and Potiskum respectively in 2018 while in 2019, yields of 0.48 and 1.52 t ha⁻¹ were obtained in Makurdi and Potiskum respectively. Number of capsules and yield of the crop (24.11, 74.70) and (0.48, 0.87 t ha⁻¹) were higher in the improved varieties than the local variety in both locations. NCRIBEN-032 with yield of 0.54 and 0.87 t ha⁻¹ in Makurdi and Potiskum in 2018 gave significantly higher yield than the other varieties. In 2019, similar results were obtained. All the varieties performed better in Potiskum than Makurdi, and this can be attributed to differences in weather and climate conditions as the elements of climate play vital roles in the type of growth environment available to the crop. Good drainage is crucial, as sesame is very susceptible to short periods of water logging (Bennet, 2011). The soils in Makurdi were waterlogged towards the end of



August, 2019 and this may be responsible for the low yield obtained there. During each of its development stages, sesame is highly susceptible to water-logging, and can therefore only thrive during moderate rainfall, or when irrigation is carefully controlled in drier regions (Naturland, 2002).

In most tropical countries, the mean yield of sesame is very low (Naturland, 2002) as a result of many production constraints which has hindered considerable yield improvement. Chude *et al.* (2012) reported that under farmers' conditions beniseed yield is between 200 and 450 kg ha⁻¹ of dry seed. However, up to 500 – 800 kg ha⁻¹ can be obtained by adopting improved practices with a plant population of 25 - 40,000 plants ha⁻¹. The yield obtained in the current study in 2018 was in the range of that reported by Chude *et al.* (2012) and yield of 700 kilograms per hectare reported by Nigeria's Harvest (2009) but in 2019, the yields were higher than those reported here. However, the yields obtained in this study in both years were lower than the 2000 kg ha⁻¹ reported by Adebowale *et al.* (2010) and Hassen (2011).

Table 1: Selected Physical and Chemical Properties of Soil of the Experimental Sites before Planting

Property	Makurdi		Potiskum	
	2018	2019	2018	2019
Chemical Property				
pH	6.08	6.50	6.96	6.70
Organic Carbon (%)	0.52	0.53	0.55	0.57
Organic Matter (%)	0.90	0.91	1.95	0.98
Total Nitrogen (%)	0.11	0.12	0.17	0.19
Available P (mg kg ⁻¹)	3.90	4.35	3.15	3.30
Exchangeable Cation (Cmol kg⁻¹)				
Ca	3.00	2.30	3.10	2.83
Mg	2.80	2.10	2.80	2.60
K	0.27	0.31	0.24	0.22
Na	0.24	0.20	0.03	0.02
EB	6.31	4.91	6.17	5.67
EA	1.10	0.90	0.20	0.18
CEC	7.41	5.81	6.37	5.85
Base Saturation (%)	85.20	84.51	96.86	96.92
Particle Size Distribution				
Sand (%)	71.8	75.50	67.10	65.00
Silt (%)	10.00	9.50	11.70	14.10
Clay (%)	18.20	15.00	21.20	20.90
Textural Class	Sandy loam		Sandy clay loam	

**Table 2: Main Effects of Varieties and Fertilizer Application on the Yield of Sesame in 2018**

Varieties	Capsule Length (cm)		No. of capsules per plant		No. of seeds per capsule		Weight of 1000 capsules (g)		Weight of 1000 seeds (g)		Seed yield (t ha ⁻¹)	
	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m
V1	3.01	3.21	13.92	43.10	48.42	52.69	337.4	380.94	137.19	221.31	0.34	0.70
V2	3.03	3.21	17.89	65.90	59.58	52.53	379.9	401.47	136.94	220.61	0.54	0.78
V3	3.03	3.20	24.11	74.70	54.94	54.92	382.5	421.72	139.69	222.92	0.48	0.87
LSD (P≤0.05)	NS	NS	3.20	22.01	NS	NS	17.19	15.24	NS	1.63	0.10	0.05
Fertilizer												
F1	2.90	3.07	12.41	59.60	50.37	43.85	348.3	408.41	122.96	209.81	0.38	0.70
F2	3.06	3.16	13.11	66.60	54.48	50.74	361.8	417.22	133.93	215.67	0.43	0.75
F3	2.99	3.39	14.04	73.40	57.11	56.11	389.1	424.26	143.81	224.07	0.44	0.78
F4	3.16	3.22	16.33	90.70	60.63	62.81	420.5	435.63	151.07	236.89	0.49	0.88
LSD (P≤0.05)	0.0345	0.063	0.84	6.08	1.47	2.78	8.63	3.44	4.62	4.03	0.0162	0.03

NS = Not significant, F1 = 0 kg ha⁻¹, F2 = 50 kg ha⁻¹, F3 = 100 kg ha⁻¹, F4 = 150 kg ha⁻¹, V1 = Jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

**Table 3: Main Effects of Varieties and Fertilizer Application on the Yield of Sesame in 2019**

Varieties	Capsule Length (cm)		No. of capsules per plant		No. of seeds per capsule		Weight of 1000 capsules (g)		Weight of 1000 seeds (g)		Seed yield (t ha ⁻¹)	
	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m
V1	2.99	3.24	14.47	76.3	68	58.89	370.1	424.50	135.42	226.83	0.43	1.10
V2	3.01	3.23	14.67	73.9	67	57.03	372.0	425.31	138.81	226.25	0.44	1.37
V3	3.02	3.24	14.92	80.2	228	60.53	375.0	425.78	140.67	228.17	0.44	1.38
LSD (P≤0.05)	0.034	NS	0.93	NS	NS	2.50	6.32	NS	5.023	NS	NS	0.15
Fertilizer												
F1	2.88	3.03	12.48	63.6	62	48.41	344.4	409.67	121.81	213.04	0.38	1.20
F2	2.99	3.16	13.59	69.2	66	54.59	361.3	419.22	133.67	221.04	0.43	1.32
F3	3.02	3.27	15.11	76.7	69	60.78	377.8	428.04	142.37	230.30	0.45	1.40
F4	3.15	3.49	17.56	97.6	288	71.48	405.9	443.85	155.33	243.96	0.49	1.57
LSD (P≤0.05)	NS	0.06	NS	6.75	NS	2.88	NS	3.79	NS	3.56	0.10	0.06

NS = Not significant, F1 = 0 kg ha⁻¹, F2 = 50 kg ha⁻¹, F3 = 100 kg ha⁻¹, F4 = 150 kg ha⁻¹, V1 = Jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032



The significant response of yield and yield attributes to fertilizer application is an indication of the role of fertilizers in plant nutrition. Nitrogen, Phosphorus and potassium are the three most limiting of the essential plant nutrient elements and are required in large quantities by crops especially in Nigerian soils with low inherent fertility (Ibrahim *et al.*, 2017). Yield and yield attributes increased with increasing levels of fertilizer application. The present findings are in conformity with the results obtained by Babaji *et al.* (2006) who reported significant increase in the yield attributes of sesame with increase in Nitrogen fertilizer.

The statuses of nutrients in soils of Nigeria especially those with a history of intensive cultivation are generally low, hence the significant response of sesame yield and its other attributes to fertilizer application. In recent times, many farmers and researchers in Nigeria have used many fertilizer types to improve the yield of sesame, but the yield still remains very low, about 450 kg ha⁻¹ (Eifediyi *et al.*, 2016), compared to yield in Egypt (1,323 kg ha⁻¹) and Ethiopia (825 kg ha⁻¹) (FAO, 2009). When soils are continually cultivated, it results in low yields due to the mining of the soil nutrients. This calls for the use of external inputs in order to reverse the loss of nutrients and maintain productivity (Agbede, 2009). The replenishment of nutrients and enhanced quality of tropical soils could be achieved through the addition of fertilizers (Shangakkara *et al.*, 2004). Fertilizer is a component of sustainable crop production systems. Sesame requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium (NPK) for good growth and high yield, hence the response of the sesame crop to fertilizer application in the current study.

Fertilizer application is one major farming operation needed to correct deficiencies in the soil in order to ensure proper growth and functioning of crops with the aim of increasing yield (Srivastava *et al.*, 2006). Adekayode and Ogunkoya (2010) observed improved maize growth parameters with corresponding higher yield in plots treated with fertilizers at 300 and 250 kg per hectare in Nigeria. The report by Bonsu (2003) that an increase in the level of fertilizer application resulted in an increase in the growth and yield parameters of sesame confirms the current result. Similarly, El-Nakhlawy and Shaheen (2009) stated that vegetative production in plants increases with an increased level of fertilizer and this is in conformity with the results of the current study. Eifediyi *et al.* (2016) also observed an increase in the number of leaves of sesame when inorganic fertilizer was used in the southern Guinea savanna zone in Nigeria.

Crops require nutrients to perform optimally both in the vegetative and reproductive stages of their life cycle however; most Nigerian soils have been reported to be deficient in these essential nutrients (Ibrahim *et al.*, 2017). Hence, the need for application of external sources for these plant nutrients. For the study under consideration, increase in yield and yield attributes with increasing levels of fertilizer application from the control plots where fertilizer was not applied to plots that received 150 kg ha⁻¹ of the NPK 15:15:15 was observed.

Responses of various crops, including sesame, soybeans, maize, ground nut, wheat and rice to fertilizer application have been studied in Nigeria (Eifediyi *et al.*, 2016; Ojeniyi *et al.*, 2016). Eifediyi *et al.* (2016) reported that NPK fertilizer significantly ($p < 0.05$) influenced the yield of sesame. The results of their study also revealed that NPK fertilizer at the rate of 400 kg ha⁻¹ and 300 kg ha⁻¹ produced the highest grain yield of sesame for 2013 and 2014 respectively; these dosage of fertilizer used in obtaining optimum yield were higher than the 150 kg ha⁻¹ in the present study. Jakusko and Usman (2013) obtained maximum yield of sesame with NPK fertilizer at the rate of 300 kg ha⁻¹ and 200 kg ha⁻¹ in 2009 and 2010 respectively.



Main Effects of Varieties and Fertilizer Application on Soil Properties

The main effects of varieties and fertilizer application on selected soil properties in 2018 and 2019 are presented on Table 8a-c and 9a-c respectively. The varieties at both locations did not have a significant difference in their effect on most of the soil properties after harvest in 2018 and 2019. The effects of fertilizer on soil properties also show no significant difference in most of the parameters studied at both locations though, most soil parameters increased with increasing levels of fertilizer application. The effects of fertilizer applications on soil physical and chemical properties are important to agricultural sustainability and to increase crop yield (Ayoola, 2006 and Agbede, 2009). The physical and chemical properties of a soil are one of the fundamental factors affecting crop growth, development and yield. This is because these properties have a very high degree of correlation with crop production and have high influence on soil fertility and crop performance (Onwudiwe *et al.*, 2014). For the study under consideration, more focus was on the chemical properties and results revealed that the soil properties were improved with increasing levels of fertilizer application though no significant difference was observed in the interaction effects of most of the soil parameters in both seasons.

Many African soils show nutrient deficiency problems after only a short period of cultivation because of their nature as well as prevailing environmental conditions. Farmers have sought to furnish additional nutrients by the application of chemical fertilizer so that the yields of crops will no longer be limited by the amount of plant nutrients that the natural system can supply (Agber *et al.*, 2012 and Agbede *et al.*, 2013). Fertilizers are usually applied to soil for increasing or maintaining crop yields to meet the increasing demand of food (Olatunji and Ibrahim, 2014; Babbu *et al.*, 2015). Application of inorganic fertilizers results in higher soil organic matter accumulation and biological activity due to increased plant biomass production and organic matter returns to soil in the form of decaying roots, litter and crop residues (Adekiya and Agbede, 2009; Babbu *et al.*, 2015). Addition of soil organic matter enhances soil organic carbon content, which is an important indicator of soil quality and crop productivity (Babbu *et al.*, 2015). Fertilizer additions also affect the chemical composition of soil solution which can be responsible for dispersion/flocculation of clay particles and thus, affects the soil aggregation stability (Haynes and Naidu, 1998).

Effects of Year of Planting and Location on the Yield of Sesame

The effects of year of planting (Table 4) on sesame yield in Makurdi indicated that yield parameters differed significantly only in the number of capsules, number of seeds per capsule and weight of 1000 capsules but not in the yield per hectare. The non-significant difference in the yield in both years is an indication that the elements of weather and climate did not differ much in those years. However, the effect of year on the yield parameters is pronounced in the Potiskum location and this is probably due to differences in rainfall and temperature in both years in this location (Table 5).

**Table 4: Effect of Year on Yield and Yield Attributes of Sesame in Makurdi**

Year	Capsule Length (cm)	No. of capsules per plant	No. of seeds per capsule	Weight of 1000 capsules (g)	Weight of 1000 seeds (g)	Seed yield (t ha ⁻¹)
2018	3.008	14.69	67.51	372.34	138.30	0.436
2019	3.024	13.97	55.65	379.94	137.94	0.436
LSD (P<0.05)	NS	0.44	1.082	3.89	NS	NS

Table 5: Effect of Year on Yield and Yield Attributes of Sesame in Potiskum

Year	Capsule Length (cm)	No. of capsules per plant	No. of seeds per capsule	Weight of 1000 capsules (g)	Weight of 1000 seeds (g)	Seed yield (t ha ⁻¹)
2018	3.23	76.79	58.81	425.19	227.08	1.37
2019	3.21	72.59	53.38	421.38	221.61	0.78
LSD (P<0.05)	NS	3.19	1.36	1.77	1.855	0.025

The effect of location indicated that Potiskum yield of 0.79 t ha⁻¹ in 2018 was higher than the 0.44 t ha⁻¹ in Makurdi while in 2019; the Potiskum yield (1.37 t ha⁻¹) was also higher than the 0.44 t ha⁻¹ obtained in Makurdi. The significant difference in the effect of the locations in 2018 could be attributed to the differences in the locations as shown in the soil properties. Yields in Potiskum were higher than Makurdi. Similar trend was obtained in 2019 where yields in Potiskum were significantly and largely higher than what was obtained in Makurdi. Potiskum and the far Northern part of Nigeria are known for large production of sesame in Nigeria (Table 6 and 7).

Table 6: Effect of Location on Yield and Yield Attributes of Sesame in 2018

Year	Capsule Length (cm)	No. of capsules per plant	No. of seeds per capsule	Weight of 1000 capsules (g)	Weight of 1000 seeds (g)	Seed yield (t ha ⁻¹)
Makurdi	3.008	14.69	67.51	372.30	138.30	0.436
Potiskum	3.208	72.59	53.38	421.40	221.60	0.778
LSD (P<0.05)	0.055	3.796	2.48	9.14	5.38	0.029

Table 7: Effect of Location on Yield and Yield Attributes of Sesame in 2019

Year	Capsule Length (g)	No. of capsules per plant	No. of seeds per capsule	Weight of 1000 capsules (g)	Weight of 1000 seeds (g)	Seed yield (t ha ⁻¹)
Makurdi	3.02	13.97	55.65	379.90	137.90	0.436
Potiskum	3.23	76.79	58.81	425.20	227.10	1.373
LSD (P<0.05)	0.042	2.44	1.91	11.17	4.91	0.028

**Table 8a: Main Effects of Varieties and Fertilizer Application on Selected Soil Properties in 2018**

Varieties	BS (%)		CEC (cmol kg ⁻¹)		Ca (cmol kg ⁻¹)		EA (cmol kg ⁻¹)		EB (cmol kg ⁻¹)		K (cmol kg ⁻¹)	
	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m
V1	85.26	89.12	7.81	6.31	3.14	3.46	1.15	0.45	6.63	5.85	0.28	0.26
V2	85.38	88.12	7.86	6.48	3.14	3.59	1.15	0.48	6.71	6.00	0.30	0.28
V3	85.33	88.57	7.73	6.24	3.07	3.40	1.13	0.48	6.60	5.74	0.27	0.26
LSD (P≤0.05)	0.73	NS	0.49	NS	0.30	NS	NS	NS	NS	NS	NS	NS
Fertilizer												
F1	84.77	88.22	7.55	6.45	3.00	3.47	1.15	0.53	6.40	5.88	0.26	0.26
F2	85.05	88.51	7.51	6.38	2.99	3.57	1.12	0.43	6.35	5.95	0.26	0.28
F3	85.90	88.63	8.02	6.30	3.19	3.48	1.13	0.43	6.89	5.87	0.29	0.27
F4	85.57	89.06	8.12	6.24	3.27	3.41	1.17	0.49	6.95	5.74	0.33	0.26
LSD (P≤0.05)	0.84	NS	0.57	NS	0.35	NS	NS	NS	0.34	NS	0.034	NS

NS= Not significant, F1 = 0 kg ha⁻¹, F2 = 50 kg ha⁻¹, F3 = 100 kg ha⁻¹, F4 = 150 kg ha⁻¹, V1 = jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

**Table 8b: Main Effects of Varieties and Fertilizer Application on Selected Soil Properties in 2018**

Varieties	Mg (cmol kg ⁻¹)		N (%)		Na (cmol kg ⁻¹)		OC (%)		OM (%)		P (mg kg ⁻¹)	
	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m
V1	2.99	1.50	0.077	0.080	0.33	0.63	0.75	0.90	1.29	1.56	3.25	3.48
V2	3.03	1.80	0.082	0.084	0.48	0.62	0.76	0.86	1.31	1.49	3.34	3.47
V3	3.02	1.49	0.080	0.080	0.39	0.59	0.69	0.87	1.18	1.50	3.19	3.55
LSD (P≤0.05)	NS	NS	0.02	0.003	NS	NS	0.06	0.03	NS	0.05	0.12	NS
Fertilizer												
F1	2.90	1.53	0.073	0.083	0.24	0.62	0.61	0.88	1.05	1.52	3.44	3.42
F2	2.89	1.50	0.074	0.082	0.34	0.61	0.69	0.87	1.18	1.51	3.19	3.43
F3	3.16	1.88	0.083	0.081	0.56	0.62	0.80	0.88	1.38	1.52	3.68	3.68
F4	3.09	1.48	0.085	0.080	0.46	0.60	0.83	0.88	1.43	1.52	2.74	3.48
LSD (P≤0.05)	NS	0.20	0.008	NS	0.12	NS	0.11	NS	0.14	NS	0.25	NS

NS= Not significant, F1 = 0 kg ha⁻¹, F2 = 50 kg ha⁻¹, F3 = 100 kg ha⁻¹, F4 = 150 kg ha⁻¹, V1 = jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

**Table 8c: Main Effects of Varieties and Fertilizer Application on Selected Soil Properties in 2018**

Varieties	pH		Sand (%)		Clay (%)		Silt (%)	
	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum
V1	6.13	6.61	69.16	71.72	19.08	15.37	11.76	12.92
V2	6.15	6.57	68.47	71.10	19.41	15.42	12.12	13.48
V3	6.14	6.57	68.68	72.00	18.70	14.95	12.51	13.05
LSD (P≤0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer								
F1	6.07	6.55	68.46	72.02	19.28	15.06	12.11	12.92
F2	6.18	6.60	69.46	71.26	17.61	15.49	12.92	13.26
F3	6.10	6.59	67.59	71.63	20.89	15.26	11.52	13.11
F4	6.21	6.59	69.56	71.51	18.48	15.19	11.96	13.30
LSD (P≤0.05)	NS	NS	NS	NS	0.14	NS	0.76	NS

NS= Not significant, F1 = 0 kg ha⁻¹, F2 = 50 kg ha⁻¹, F3 = 100 kg ha⁻¹, F4 = 150 kg ha⁻¹,

V1 = jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

**Table 9a: Main Effects of Varieties and Fertilizer Application on Selected Soil Properties in 2019**

Varieties	BS (%)		CEC (cmol kg ⁻¹)		Ca (cmol kg ⁻¹)		EA (cmol kg ⁻¹)		EB (cmol kg ⁻¹)		K (cmol kg ⁻¹)	
	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m	Makur di	Potisku m
V1	84.26	92.20	7.74	6.35	3.13	3.48	1.22	0.45	6.52	5.87	0.28	0.34
V2	84.28	91.39	7.61	6.58	3.07	3.61	1.19	0.56	6.41	6.02	0.28	0.28
V3	84.20	90.62	7.74	6.34	3.14	3.44	1.22	0.58	6.52	5.71	0.29	0.26
LSD (P≤0.05)	NS	NS	NS	0.19	NS	0.17	NS	0.05	NS	NS	NS	NS
Fertilizer												
F1	83.79	90.47	7.26	6.54	2.88	3.52	1.18	0.60	6.08	5.87	0.22	0.27
F2	83.98	91.45	7.77	6.50	3.21	3.60	1.24	0.50	6.52	5.97	0.25	0.27
F3	84.28	92.86	7.66	6.31	3.05	3.50	1.20	0.43	6.46	5.88	0.32	0.37
F4	84.95	90.85	8.09	6.33	3.28	3.44	1.22	0.57	6.87	5.76	0.34	0.25
LSD (P≤0.05)	NS	1.56	0.49	NS	0.30	NS	NS	0.06	0.51	NS	0.02	NS

NS= Not significant, F1 = 0 kg ha⁻¹, F2 = 50 kg ha⁻¹, F3 = 100 kg ha⁻¹, F4 = 150 kg ha⁻¹, V1 = jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

**Table 9b: Main Effects of Varieties and Fertilizer Application on Selected Soil Properties in 2019**

Varieties	Mg (cmol kg ⁻¹)		N (%)		Na (cmol kg ⁻¹)		OC (%)		OM (%)		P (mg kg ⁻¹)	
	Makur	Potisku	Makur	Potisku	Makur	Potisku	Makur	Potisku	Makur	Potisku	Makur	Potisku
	di	m	di	m	di	m	di	m	di	m	di	m
V1	2.87	1.50	0.077	0.082	0.24	0.63	0.62	0.90	1.07	1.56	3.64	3.49
V2	2.83	1.52	0.073	0.085	0.24	0.61	0.57	0.86	0.98	1.48	3.55	3.48
V3	2.87	1.49	0.077	0.079	0.24	0.58	0.62	0.87	1.06	1.50	3.69	3.56
LSD (P≤0.05)	NS	NS	NS	0.004	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer												
F1	2.77	1.53	0.053	0.083	0.21	0.62	0.66	0.87	1.14	1.51	2.50	3.44
F2	2.84	1.50	0.063	0.081	0.23	0.60	0.43	0.87	0.75	1.49	3.45	3.43
F3	2.84	1.50	0.087	0.082	0.24	0.61	0.55	0.88	0.95	1.52	3.85	3.69
F4	2.97	1.48	0.099	0.081	0.27	0.59	0.76	0.88	1.32	1.52	4.72	3.49
LSD (P≤0.05)	NS	NS	0.005	NS	0.03	NS	0.06	NS	0.13	NS	0.41	NS

NS= Not significant, F1 = 0 kg ha⁻¹, F2 = 50 kg ha⁻¹, F3 = 100 kg ha⁻¹, F4 = 150 kg ha⁻¹, V1 = jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

**Table 9c: Main Effects of Varieties and Fertilizer Application on Selected Soil Properties in 2019**

Varieties	pH		Sand (%)		Clay (%)		Silt (%)	
	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum
V1	6.32	6.61	69.48	71.50	18.99	15.37	11.81	13.13
V2	6.30	6.57	69.30	71.10	18.56	15.51	12.14	13.39
V3	6.32	6.57	69.23	71.84	18.69	14.95	12.08	13.21
LSD ($P \leq 0.05$)	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer								
F1	6.57	6.55	69.18	71.52	19.82	15.17	11.00	13.31
F2	6.18	6.60	69.56	71.26	17.96	15.49	12.48	13.26
F3	6.29	6.59	70.49	71.52	16.98	15.26	12.90	13.22
F4	6.23	6.59	68.13	71.62	20.22	15.19	11.65	13.19
LSD ($P \leq 0.05$)	0.18	NS	NS	NS	0.77	NS	NS	NS

NS= Not significant, F1 = 0 kg ha⁻¹, F2 = 50 kg ha⁻¹, F3 = 100 kg ha⁻¹, F4 = 150 kg ha⁻¹,

V1 = jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032



CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, the improved varieties performed better than the local variety in terms of yield at both locations. In 2019, the highest yields in Makurdi and Potiskum were obtained with NCRIBEN-032. All the varieties performed better in 2018 than 2019 at both locations. The effects of varieties on soil properties did not differ significantly. However, the improved varieties left lower essential nutrients in soil and the local variety gave higher values in soil properties after harvest. The effect of the year of planting did not influence yield significantly in both cropping seasons. The effects of the planting on soil properties indicated that the soil properties were higher in 2018 in Makurdi but higher in 2019 in Potiskum. The effect of location indicated that Potiskum yield in 2018 was higher than that of Makurdi. Similar yield results were obtained in 2019 for both locations. Location effect showed that the Potiskum soil had more nutrients than that of Makurdi. Fertilizer application at 150 kg ha⁻¹ of NPK 15:15:15 favoured the retention of organic matter as well as other essential nutrient elements in soil and is hereby recommended for sustainable sesame production in both locations.

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