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Full Length Research Paper

Productivity of sesame (*Sesamum indicum* L.) varieties as influenced by tillage practices in two agro-ecological zones of Nigeria

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ABSTRACT: Field experiments were carried out in 2018 and 2019 cropping seasons to determine the productivity of sesame varieties as influenced by tillage practices in Makurdi, southern guinea savanna, and Potiskum, Sudan savanna agro-ecological zones of Nigeria. Treatments consisted of three varieties of sesame (Jigida, NCRIBEN-01M, and NCRIBEN-032) and three levels of tillage practices (zero tillage, flatbeds, and ridges). 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. The 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 improved varieties performed better than the local varieties in terms of yield. Crop performance was higher in Potiskum than Makurdi. Ridges produced higher yields followed by flatbeds and then zero tillage at Makurdi and Potiskum. The effects of variety on soil properties did not differ significantly however, the improved varieties left lower essential nutrients in the soil. Zero tillage retained higher nutrients and organic matter in the soil while ridges gave lower values for essential nutrients and organic matter. For sustainable sesame production in both locations, it can be recommended that sesame should be grown on ridges. For conservation/retention of essential nutrients and organic matter in the soil, zero tillage is recommended for both locations.

Keywords: Sesame varieties, tillage, yield, southern guinea and sudan savanna, Nigeria

INTRODUCTION

Sesame (*Sesamum indicum* L.), one of the oldest oilseed crops and has been cultivated in tropical and subtropical areas since ancient times. It is an important crop because of its high oil content (Uzun *et al.,* 2012), and great antioxidant value (Biswas *et al.,* 2001 and Iwo *et al.,* 2002). In Nigeria, sesame is becoming an important component of Nigeria's agricultural exports given its current rate of cultivation. Sesame is the third largest export commodity in Nigeria after petroleum and cocoa (USAID, 2002). The potentials of sesame production in Nigeria are high, with an estimated 3.5 million hectare of agricultural land devoted for its cultivation in the savanna zones (Eifediyi *et al.,* 2016).

The sesame seeds serve as ingredients in soup and the oil is used for cooking, baking, candy making, soaps, lubricant, body massage, hair treatment, food manufacture, industrial uses and alternative medicine for blood pressure, aging, stress and tension (Ahmed *et al.,* 2009). Furthermore, sesame crop can grow well under tropical and subtropical climates with low rainfall, and can also grow as mixed stands with diverse crops (NCRI, 2002). Today, both the white and brown types are commonly grown by smallholder farmers in Adamawa, FCT Abuja, Benue, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Kogi, Nasarawa, Plateau, Taraba and Yobe State (USAID, 2002; Iorlamen *et al.,* 2014). The high demand for sesame and its products at both National and International levels led to the present huge market potential for the crop. However, owing to its previous status as a minor crop, there has been little research efforts towards improved production of the crop (NCRI, 2002). Tillage is performed to loosen the soil and produce a good tilth with a significant impact on sesame production especially through the improvement of soil properties and provision of a suitable seedbed for good seed germination, easy emergence and good establishment of seedling by way of enhanced root growth (Okeleye and Oyekanmi, 2003; Alam *et al.,* 2014; Ali *et al.,* 2006). In Nigeria, farmers commonly till the soil to improve its physical, chemical, and biological characteristics that alter plant growth and yield (Agber *et al.,* 2017). Crops show symptoms of water and nutrient deficiencies when grown without tillage because of high surface bulk density, low porosity and retarded infiltration (Ali *et al.,* 2015). However, the conventional and traditional tillage methods have negative effects on soil life and increase mineralization of organic matter. A zero tillage system, on the other hands, is a conservation method that involves the use of crop residues that aid water infiltration, prevent erosion, and increase organic matter content and agricultural productivity (Ali *et al.,* 2015). Survey reports by various researchers in the agro-ecological zones of Nigeria revealed that the yield of the sesame crop is low, probably due to lack of improved varieties and poor tillage practices carried out 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 rarely use improved varieties to increase the yield. Studies have shown that the crop performs well with the appropriate tillage practices (Eifediyi *et al.,* 2016 and Eifediyi *et al.,* 2018) and improved varieties. For sustainable production of sesame, there is need for adoption of improved varieties and tillage practices that would ensure optimum yield. Therefore, the present study was undertaken to determine the response of sesame varieties to tillage practices with a view to sustaining productivity as well as enhancing the farmers' level of sesame production through appropriate tillage practices across the southern guinea and sudan savanna agro-ecological zones of Nigeria.

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-Nigeria to determine the productivity of sesame varieties as influenced by tillage practices. 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 0C. It is located between latitude 70 41' N to 70 42' N and longitude 80 37' E to 80 38' E. Potiskum location falls within the sudan savanna zone of Nigeria with mean rainfall of about 800 mm per annum and temperature of 39 – 42ºC. It is located between latitude 110 42' N to 110 43' N and longitude 110 04' E to 110 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 for both locations consisted of three varieties of sesame (Jigida, NCRIBEN-01M and NCRIBEN-032) and three levels of tillage practices (zero tillage, flat beds and ridges). The treatments were laid out in a RCBD with sesame varieties occupying the main plots and tillage practices 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 bed and ridges were made using 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. 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 turn 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) the mean weights were then 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

Soil properties of the experimental site before planting

Selected soil properties of the experimental sites indicate that both soils were sandy loam (Makurdi) and sandy clay loam (Potiskum) in texture and are presented in (Table 1). 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 years respectively (71.8 and 67.10 %) was indicative of the low clay content which could be attributed to the soil separates 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 indicate that the soils are good for sesame production because 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 in solation and rainfall prevents the build-up of organic matter which is the store house 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.

Main effects of variety and tillage practices on the yield of sesame

Table 2 shows the main effects of the sesame variety and tillage practices on the yield of sesame in the 2018 and 2019 cropping seasons. Results indicated that the varieties had significant difference 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 difference 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

Table 1: Selected Soil Properties 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 (mgkg^{-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	

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, 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 ending 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; Arafa, 2007).

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 and locations were lower than the 2000 kg ha-1 reported by Adebowale *et al.* (2010) and Hassen (2011).

The variability in yield and yield attributes as influenced by tillage practices in (Table 3) in both years and in both locations could be attributed to differences conferred on the soil properties by the different tillage practices. Numbers of capsules per plant, number of seeds per capsule, weights of 1000 seeds and capsules as well as yield were all higher in the ridged plots followed by flat beds and then the zero tilled plots. The higher yield in ridged plots could be attributed to the fact that tillage greatly affected soil moisture and temperature, which in turn affected plant nutrient dynamics in soil (Ahmed *et al.*, 2009). In improving soil condition, tillage is a key factor and plays a significant role in improving crop growth and yield (Wasaya *et al.*, 2011).

The success or failure of crop production systems depends on seedbed environment. Generally tillage improves soil bulk density, water storage capacity and soil penetration. Halvorson *et al.* (2001) and Dinnes *et al.* (2002) reported that tillage operations and soil disturbance can generally cause an increase in soil aeration and nutrient mineralization for crop use. In 2019,

Table 2: Main effect of variety and tillage practices on the yield of sesame in 2018.

Variety	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	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum
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≤0.0)	NS	NS	3.20	22.01	NS	NS	17.19	15.24	NS	1.63	0.10	0.05
Tillage												
Flat	3.98	3.21	18.64	73.00	54.42	53.67	381.3	423.33	133.17	220.75	0.43	0.79
Ridged	3.03	3.36	23.81	83.90	55.39	57.83	387.6	429.14	138.53	229.53	0.45	0.86
Zero	2.98	3.06	14.47	60.80	57.14	48.64	371.8	411.67	122.14	214.56	0.42	0.69
LSD (P≤0.05)	NS	NS	4.21	5.72	1.27	2.02	7.47	3.19	3.90	3.97	0.014	0.04

NS= Not significant, V1 = jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

Table 3: Main effect of variety and tillage practices on the yield of sesame in 2019

Variety	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	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum
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
Tillage												
Flat	2.98	3.26	14.06	78.2	67	59.56	363.9	427.08	133.06	226.14	0.45	1.40
Ridged	3.00	3.40	14.67	87.6	68	64.39	372.1	433.78	138.89	236.72	0.48	1.52
Zero	3.05	3.05	15.33	64.6	229	52.50	381.1	414.72	142.94	218.39	0.40	1.20
LSD (P≤0.05)	0.029	0.05	0.80	5.84	NS	2.50	5.48	3.29	4.350	3.08	0.014	0.05

NS= Not significant, V1 = Jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

results indicated that the performances of the varieties were largely influenced by the type of tillage practice they were grown on at both locations.

Zero tilled soils gave the least yield of all the tillage practices in both locations (0.42 and 0.69 t ha-1 respectively). Zero tilled soils are usually compacted and a compacted soil layer, because of its high bulk density and low porosity confines the crop roots in the upper layer thereby reducing the volume of soil that can be explored by the crop for nutrients and water (Lipiec *et al.,* 2003).

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

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

The zero tilled plots having the least yield could be due to restricted oxygen supply, restricted root hair growth and high concentration of CO_2 in the soil which may be toxic to the roots. The critical limit of CO_2 for most species is between 10 to 20 % (Prohar *et al.,* 2000). Gajri and Majumdar (2002), listed disadvantages of zero tillage to include difficulty in sowing operations, slow rate of organic matter decomposition and pollution problems associated with continuous use of chemical pollution in fields with problematic weeds. Responses of various crops, including sesame, soybeans, maize, ground nut, wheat and rice to tillage practices have been studied in Nigeria (Senjobi *et al.,* 2013; Ali *et al.,* 2015). Uzun *et al.,* (2012) reported that the lowest yield of post wheat second crop sesame was recorded for zero till with a value of 413.0 kg ha-1. This is similar with results obtained in this study were zero tilled plots gave the lowest yields in both locations.

Senjobi *et al.* (2013) also reported that there was significant difference in soil parameters among the tillage practices. Their result is in conformity with the present study where the ridged tillage system resulted in the most favorable soil environment, for crop growth and best performance of crop followed by flat bed and no-tillage practice in the area studied respectively. The significant difference in yields was adduced to lower bulk density, higher water holding capacity and porosity which increased plant root proliferation and optimal utilization of soil nutrients under ridged plots. Hence ridges have the capacity to increase production while zero till is better for sustainable and improved soil properties.

The report by Ali *et al.* (2015) was also similar to results obtained in this study. They reported that tillage practices significantly increased the mean values of crop parameters studied. Yield components were significantly lower in no-tillage than ridge tillage. Grain yields in the no-tillage plots were also lower compared to other tillage methods. This they attributed to reduced vertical root distribution in no-tilled plots, which reduced the soil depth explored by their roots. Similarly Agber *et al.* (2017) reported that tillage methods significantly affected maize growth and yield and that the lowest yield values were observed in no tillage plots as compared to ridged and flat bed.

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 significance 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 effects 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 as presented in (Table 5).

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. Yield in Potiskum were higher than Makurdi. Similar trend was obtained in 2019 where yield 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 (Tables 6 and 7).

Main Effects of Variety and Tillage Practices on Selected Soil Properties

The main effects of variety and tillage practices on selected soil properties in 2018 and 2019 are presented in (Tables 8a-c and 9a-c) respectively. The varieties at both locations did not have significant difference in their effect on most of the soil properties after harvest in 2018 and 2019 at both locations.

The effects of tillage on soil properties also show no significant difference in most of the parameters studied at both locations. Tillage operations are known to influence both the release and conservation of soil nutrients. The effects of tillage practices on nutrients at both locations indicated that the zero tilled plots had higher nutrients followed by the flat beds while the ridged plots had the least available in both years.

The higher nutrient status of zero tillage can be attributed to the presence of mulch on the surface due to decomposed plant residues, which led to enhanced soil organic matter status and associated availability of nutrients (Agbede, 2008).

Tillage systems that reduce soil disturbance and residue incorporation have generally been observed to increase soil organic matter content (Mrabet *et al*., 2001). Ismail *et al.* (1994) concluded that conservation tillage systems results in significant and positive effects on several chemical soil properties. Soil organic matter largely contributes to nutrient cycling and thus supplies of N, S and other elements (Saleque *et al.,* 2009).

Several researchers observed an increase of soil organic matter and carbon with conservation tillage practices in the top soil layer (Bronick and Lal, 2005; Vogeler *et al.,* 2009).

In general, tillage improves the decomposition of crop residues by facilitating contact between plant tissue and soil aggregate surfaces, the primary biome of soil microorganisms (Bronick and Lal, 2005). In addition, accumulation of considerable amounts of total nitrogen, phosphorus (P), and potassium with conservation tillage was observed (Calegari *et al.,* 2013). This may be due to the fact that the land was not disturbed which increased the buildup of soil organic matter, resulting in high organic carbon which reflects a reduced rate of leaching in the soil profile in the soil studied. Tillage systems (zero tillage) that reduce soil disturbance and residue incorporation have generally been observed to increase organic C.

Zero tillage has been reported to have resulted in increased in organic C content which in turn enhances soil quality and resilience (Abid and Lal, 2008). Differences in available N among tillage systems observed in the current study are in agreement with those of other studies (Martin-Rueda *et al.,* 2007). Available N was significantly higher in zero tillage treatment than in the other tillage systems at both locations.

Similarly, a study on Mollisols in Nebraska, available N was significantly greater under zero tillage than conventional tillage (Martin-Rueda *et al.,* 2007). In another study, soil available N content was also significantly increased under zero or minimum tillage (Martin-Rueda *et al.,* 2007). Higher Nitrogen in the zero tilled soils may be attributed to less loss through immobilization, volatilization, denitrification, and leaching (Malhi *et al.,* 2001).

Available P and K as well as other essential nutrient elements were higher under zero treatment probably due to higher soil organic C level. Zibilske *et al.* (2002) reported that improvement of soil available P was due to redistribution or mining of P at lower soil depths. Also, work done by Redel *et al.* (2007), showed a high amount of P under zero tillage treatment compared to the conventional tillage and have attributed this to an increase in contact time between P and soil particles.

Cultivation also stimulates soil carbon losses due to accelerated oxidation of soil carbon by microbial action. Hence when organic matter is lost the associated nutrients are also lost.

Yin and Vyn (2002) also observed more soil nutrients in case of no-tillage as compared to deep tillage. The least values of essential nutrients recorded by the ridged plots compared with the zero tilled plots could be due to inversion of top soil during soil preparation, which brought less fertile subsoil to the surface in addition to possible leaching (Ali *et al.,* 2006) as well as rapid mineralization and uptake of nutrients by the crops (Adekiya *et al.,* 2009).

Similarly, Alam *et al.,* (2014) reported that tillage practices showed positive effect on soil properties and crop yields, Bulk and particles densities were decreased due to tillage practices having the highest reduction of these properties and the highest increase of porosity and field capacity in zero tillage.

The highest total N, P, K and S in their available forms was recorded in zero tillage. Therefore, zero tillage was found to be good for soil health and achieving optimum yield of crops.

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 effect of variety and tillage practices on selected soil properties in 2018.

Variety	BS (%)		CEC (cmol kg^{-1})		Ca (cmol kg^{-1})		EA (cmol kg^{-1})		EB (cmol kg^{-1})		K (cmol kg^{-1})	
	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum
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
Tillage												
Flat	85.42	88.17	7.86	6.40	3.14	3.54	1.15	0.47	6.72	5.93	0.28	0.27
Ridged	85.32	89.22	7.78	6.16	3.10	3.29	1.14	0.57	6.64	5.56	0.28	0.25
Zero	85.23	88.42	7.75	6.47	3.11	3.62	1.14	0.37	6.58	6.10	0.29	0.28
LSD (P≤0.05)	0.73	NS	0.49	NS	0.30	0.22	NS	0.08	NS	0.39	NS	NS

NS= Not significant, V1 = Jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

Table 8b: Main effect of variety and tillage practices on selected soil properties in 2018.

Variety	Mg (cmol kg^{-1})		N (%)		Na (cmol kg^{-1})		OC (%)		OM (%)		P (mg kg^{-1})	
	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum
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
Tillage												
Flat	3.06	1.50	0.079	0.083	0.47	0.62	0.71	0.88	1.23	1.52	3.22	3.29
Ridged	2.97	1.45	0.076	0.079	0.48	0.57	0.70	0.86	1.21	1.49	3.31	3.91
Zero	3.01	1.83	0.081	0.083	0.25	0.64	0.78	0.89	1.34	1.54	3.25	3.30
LSD (P≤0.05)	NS	NS	NS	0.002	0.08	0.04	0.06	NS	0.15	NS	NS	0.312

NS= Not significant, V1 = Jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

Table 8c: Main effect of variety and tillage practices on selected soil properties in 2018.

Variety	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
Tillage								
Flat	6.14	6.57	68.94	71.78	19.00	15.07	12.04	13.15
Ridged	6.13	6.56	68.72	72.60	18.92	14.54	12.00	12.86
Zero	6.15	6.61	68.65	70.43	19.28	16.13	12.35	13.43
LSD (P≤0.05)	NS	NS	NS	1.49	NS	0.72	NS	NS

NS= Not significant, V1 = Jigida, V2 = NCRIBEN-01M, V3 = NCRIBEN-032

Table 9a: Main Effects of Variety and Tillage Practices on Selected Soil Properties in 2019.

Variety	BS (%)		CEC (cmol kg^{-1})		Ca (cmol kg^{-1})		EA (cmol kg^{-1})		EB (cmol kg^{-1})		K (cmol kg^{-1})	
	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum
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
Tillage												
Flat	84.02	91.76	7.61	6.48	3.07	3.57	1.21	0.52	6.39	5.96	0.29	0.34
Ridged	84.41	89.61	7.84	6.22	3.17	3.32	1.22	0.64	6.62	5.58	0.28	0.25
Zero	84.31	92.84	7.64	6.57	3.08	3.65	1.20	0.42	6.44	6.06	0.28	0.28
LSD (P≤0.05)	NS	1.35	NS	0.19	NS	0.16	NS	0.05	NS	0.32	NS	NS

Table 9b: Main effects of variety and tillage practices on selected soil properties in 2019.

Variety	Mg (cmol kg^{-1})		N (%)		Na (cmol kg^{-1})		OC (%)		OM (%)		P (mg kg^{-1})	
	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum	Makurdi	Potiskum
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
Tillage												
Flat	2.81	1.51	0.075	0.083	0.23	0.62	0.56	0.88	0.97	1.51	3.64	3.30
Ridged	2.93	1.45	0.075	0.085	0.24	0.57	0.70	0.86	1.21	1.48	3.76	3.92
Zero	2.84	1.56	0.076	0.079	0.24	0.64	0.55	0.89	0.94	1.54	3.49	3.32
LSD (P≤0.05)	NS	NS	NS	NS	NS	0.05	0.05	NS	0.11	NS	NS	0.25

Table 9c: Main effect of variety and tillage practices on selected soil properties in 2019

Variety	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≤0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Tillage								
Flat	6.30	6.62	70.00	71.73	18.19	15.07	12.08	13.20
Ridged	6.34	6.57	68.38	72.35	19.84	14.54	11.78	13.11
Zero	6.30	6.56	69.64	70.36	18.20	16.22	12.16	13.43
LSD (P≤0.05)	NS	NS	NS	1.34	0.67	0.65	NS	NS

NS= Not Significant, V1= Jigida, V2= NCRIBEN-01M, V3= NICRIBEN-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. Ridges produced higher yields followed by flat beds and then zero tillage in both locations. The effect of year of planting did not influence yield significantly in Makurdi but in Potiskum the yield of in 2018 was significantly higher than the yield in 2019. 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. The effects of variety 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. Zero tillage retained higher nutrients and organic matter in soil while ridges gave lower values for essential nutrients and organic matter. Location effect showed that the Potiskum soil had more nutrients than that of Makurdi. The effects of year of planting on soil properties indicated that the soil properties were higher in 2018 in Makurdi but higher in 2019 in Potiskum. Therefore, for sustainable sesame production in both locations, it can be recommended that sesame should be grown on ridges. For conservation/retention of essential nutrients and organic matter in soil, zero tillage can be recommended for both locations.

REFERENCES

Abid M, Lal R (2008). Tillage and drainage impact on soil quality, aggregate stability, carbon and nitrogen pools. *Soil and Tillage Research*, 100(1-2) 89–98.

Adebowale AA, Sanni SA, Falore OA (2010). Varietal differences in the physical properties and proximate composition of elite sesame seeds. *Libyan Agricultural Research Center Journal International* 1 (2): 103-107.

Adekiya AO, Agbede TM, Ojomo AO (2009). Effect of tillage methods on soil properties, nutrient contents, growth and yield of tomato on an Alfi sol of southwestern Nigeria. *American-Eurasian Journal of Sustainable Agriculture* 3(3): 348–353.

Aduayi EA, Chude VO, Adebusuyi BA, Olayiwola SO (2002). Fertilizer Use and Management Practices for Crops in Nigeria. 3rd ed. Garko international limited. 67-70.

Agbede TM (2008). Nutrient availability and cocoyam yield under different tillage practices. *Soil and Tillage Research* 99(1): 49–57.

Agber PI, Akubo JY, Abagyeh SOI (2017). Effect of tillage and mulch on growth and Performance of maize in Makurdi, Benue State, Nigeria. *International Journal of Environment, Agriculture and Biotechnology* 2(6):2889-2896.

Ahmed HG, Aliyu U, Haruna AB, Isa YS, Muhammad AS (2009). Effects of planting date and weeding regimes on growth and yield of sesame (*Sesamum indicum* L.) in Sokoto, North-Western Nigeria. *Nigerian Journal of Basic and Applied Science,* 17(2): 202-206.

Akinoso R, Aboaba SA, Olayanju TMA (2010). Effects of moisture content and heat treatment on peroxide value and oxidative stability of un-refined sesame oil. *AJFAND,*10 (10): 4268- 42850.

Alam MK, Islam MM, Salahin N, Hasanuzzama M (2014). Effect of tillage practices on soil properties and crop productivity in wheat-mung bean-rice cropping system under subtropical climate conditions. *The Scientific World Journal,* 10: 1-15.

Ali A, Ayuba SA, Ojeniyi SO (2006). Effect of tillage and fertilizer on soil chemical properties, leaf nutrient content and yield of soybean in the guinea savanna zone of Nigeria. *Nigerian Journal of Soil Science.* 16:126-135.

Ali A, Ibrahim NB, Usman M (2015). Yield of maize-soybean intercrop and soil properties as influenced by fertilizer in the Southern Guinea Savanna Zone of Nigeria. *International Journal of Scientific and Research Publications,* (5)7:1-9.

Anjembe BC (2004). Evaluation of Sulphur Status for Groundnut Production in Some Selected Soils of Benue State, Nigeria. M.Sc Thesis. University of Agriculture, Abeokuta, Nigeria.70 Pp.

Bennet M (2011). Sesame seed: A Handbook for Farmers and Investors. 29/08/11. Available at www.agmrc.org/media/cm/sesame_38F4324EE52CB.pdf

Biswas TK, Sana NK, Badal RK, Haque EM (2001). Biochemical study of some oil Seeds (Brassica, Sesame & Linseed). *Pakistan Journal of Biological Sci*ences 4:1002–1005.

Bouyocous GH (1951). A Recalibration of the Hydrometer Method for making the Mechanical Analysis. *Agronomy Journal.* 43: 434-438.

Bray RH, Kurtz LT (1945). Determination of total organic and available forms of phosphorus in soils. *Soil Science.* 59: 39-45.

Bremner JM, Mulraney CS (1982). Nitrogen Total In: Methods of Soil Analysis 2nd ed. A.L. Page *et al*., (Eds) ASA, SSSA Medison Winsconsin. Pp. 595-624.

Bronick CJ, Lal R (2005). Soil structure and management: a review, *Geoderma*, 124 (1-2):3–22.

Calegari A, Tiecher T, Hargrove WL (2013). Long-term effect of different soil management systems and winter crops on soil acidity and vertical distribution of nutrients in a Brazilian Oxisol, *Soil and Tillage Research*, 133:32–39.

Chude VO, Olayiwola SO, Daudu C, Ekeoma A (2012). Fertilizer Use and Management Practices for Crops in Nigeria. 4th edition Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development.Abuja. Pp.224

Dinnes DL, Karlen DL, Jaynes DB, Kaspar TC, Hatfield JL, Colvin TS, Cambardella CA (2002). Nitrogen management strategies to reduce nitrate leaching in tile-drained Midwestern soils. *Agronomy Journal,* 94: 153-171.

Eifediyi EK, Ahamefule HE, Ojiekpon IF, Agbede T M, Remison SU, Aliyu TH, Olukayode TO, Bangura AK (2016). Response of sesame (*Sesamum indicum* L.) to mulching and inorganic fertilizer application in a Southern Guinea Savanna Zone of Nigeria. *Agriculture & Forestry,* 6(2): 201-216.

Eifediyi EK, Komolafe OA, Ahamefule HE, Folola A (2018). Effect of tillage and poultry manure rates on physiological growth and yield of sesame (Sesamum indicum L.). *Plant Sciences: Scientia Agriculturae Bohemica,* 49(4):255-266.

Esu IE (1991). Detailed Soil Survey of NIHORT Farm at Bunkure Kano state, Nigeria. Institute of Agricultural Research, Zaria. p.72.

Gajri PR, Majumdar SP (2002). Fundamentals of Soil Science. *Indian Society of Soil Science,* Indian Agricultural Research Institute, New Delhi. Pp. 125-132.

Halvorson AD, Wienhold BJ, Black AL (2001). Tillage and nitrogen fertilization influence grain and soil nitrogen in an annual cropping system. *Agronomy Journal*, 93: 836-841.

Hassen R (2011). Sesame profile. Retrieved on 19/08/11. Available on line at http://www.agmrc.org/commodities__products/grains__oilseeds/sesame_profile.cfm

Iorlamen T, Ayam FM, Akombo RA (2014). Growth and yield responses of sesame (*Sesamu indicum* L.) to foliar and soil applied fertilizer in Makurdi, Benue State. *International Journal of Scientific Research and Management,* 2(2): 528-541.

Ismail I, Blevins RL, Frye WW (1994). Long-term no-tillage effects on soil properties and continuous corn yields. *Journal of Soil Science Society of America*. 58: 193-198.

Iwo GA, Idowo AA, Ochigbo AA (2002). Evaluation of sesame genotypes for yield stability and selection in Nigeria. *Nigerian Agricultural Journal,* 33:76–82.

Jakusko BB, Usman BD (2013). Effect of NPK fertilizer and plant density on productivity of sesame (*Sesamum indicum* L.). *Research Journal of Agricultural and Environmental Management,* 2(5): 121-126.

Lipiec J, Medvedev VV, Birkas M, Dumitru E, Lyndina TE, Rousseva S, Fulajtar E (2003). Effect of soil compaction on root growth and crop yield in Central and Eastern Europe. Int. Agrophy. 17: 61-69.

Malgwi WB, Ojaguna AG Chude VO, Kparmwang T Raji BA (2008). Morphological and Physical Properties of some Soils at Samaru, Zaria, Nigeria. *Nigeria Journal of Soil Research,* 1: 58 – 64.

Malhi SS, Grant CA, Johnston AM, Gill KS (2001). Nitrogen fertilization management for no-till cereal production in the Canadian Great Plains: a review *Soil and Tillage Research*, 60 (3–4):101–122.

Martin-Rueda I, Munoz-Guerra LM, Yunta F, Esteban E, Tenorio JL, Lucena JJ (2007). Tillage and crop rotation effects on barley yield and soil nutrients on a *Calciortidic haploxeralf*, *Soil and Tillage Research*, 92 (1-2): 1–9.

Mrabet R, Saber N, El-Brahli A, Lahlou S, Bessam F (2001). Total Particulate organic matter and structural stability of a calcieroll soil under different wheat rotation and tillage systems in a semi- arid area of Morocco. *Soil and Tillage Research,* 57: 225-235.

Naturland (2002). Organic farming in the Tropics and Subtropics: Sesame. 21/07/11.Available at: www.naturland.de/fileadmin/MDB/documents/Publication/English/sesame.pdf

NCRI (2002). Guide to beniseed (sesame) production. Oilseed Research Program. NCRI, Badeggi. Pp.4-5.

Nigeria's Harvest (2009). Small seed provides large income. Vol. 5, No 21.Retrieved on 21/10/09. Available on line at http://www.nigeriamarkets.org/files/Nigeria%27s_Harvest_Exporting_Nigerian_Sesame.pdf

Odunze AC (2006). Soil properties and management strategies for some sub humid Savanna zone Alfisols in Kaduna State, Nigeria. *Samaru Journal Agriculture Research*. 22:3-14.

Okeleye KA, Oyekanmi AA (2003). Influence of tillage systems and nitrogen fertilizer levels on growth and yield of maize. *Moor Journal of Agricultural Research.* 4(1): 26-36.

Prohar SS, Gajri PR, Benbi DK, Arora VK (2000). Intensive Cropping – Efficient Use of Water, Nutrients and Tillage. Food Products Press: An Imprint of Haworth Press, Inc., New York. Pp. 264-266.

Redel YD, Rubio R, Rouanet JL, Borie F (2007). Phosphorus bioavailability affected by tillage and crop rotation on a Chilean volcanic derived Ultisol, *Geoderma*, 139 (3- 4):388–396.

Saleque MA, Mahmud MNH, Kharun A, Haque M M, Hossain ATMS, Zaman SK (2009). Soil qualities of saline and non-saline deltas of Bangladesh. *Bangladesh Rice Journal,* 14 (1&2): 99- 11.

Senjobi BA, Ande OT, Okulaja AE (2013). Effects of tillage practices on soil properties under maize-cultivation on Oxic paleustalf in South Western Nigeria. *Open journal of Soil Science,* 3: 163-168.

USAID (2002). *Overview of the Nigerian sesame industry.* Washington DC: Chemonic International Inc. Pp. 20-50.

Uzun B, Yol E, Furat S, Topakci M, Canakci, M Karayel D (2012). The effects of different tillage methods on the post-wheat second crop sesame: seed yield, energy budget and economic return. *Turkey Journal of Agriculture* 36:399-407.

Vogeler I, Rogasik J, Funder U, Panten K, Schnug E (2009). Effect of tillage systems and P-fertilization on soil physical and chemical properties, crop yield and nutrient uptake, *Soil and Tillage Research*, 103 (1):137–143.

Wasaya A, Tahir M, Manaf A, Ahmed M, Kaleem S Ahmad I (2011). Improving maize productivity through tillage and nitrogen management. *African Journal of Biotechnology,* 10(81):19025-19034.

Yin XH, Vyn, TJ (2002). Soybean responses to potassium placement and tillage alternatives following no till. *Agronomy Journal,* 94: 1367-1374.

Zibilske LM, Bradford JM, Smart JR (2002). Conservation tillage induced changes in organic carbon, total nitrogen and available phosphorus in a semi-arid alkaline subtropical soil, *Soil and Tillage Research*, 66 (2):153–163.

YSGN (2008). Yobe State Ministry of Information; 2008. Available: http://zodml.org/Nigeria/Geography/Yobe State/