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# Effects of Tillage and Fertilizer on Soil Properties and Yield of Sesame Varieties in Makurdi, Nigeria

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## ABSTRACT

Field experiments were undertaken during the cropping seasons (August- December) of 2018 and 2019 at the Teaching and Research Farm, Federal University of Agriculture, Makurdi-Nigeria. The objective of the study was to determine the effects of tillage and fertilizer on soil properties and yield of sesame varieties with a view to identify appropriate tillage practice (s) and fertilizer rate that will give optimal yield of sesame. Treatments consisted of three varieties of sesame (Jigida, NCRIBEN-01M and NCRIBEN-032), three levels of tillage practices (zero tillage, flat beds and ridges) and four levels of NPK 15:15:15 fertilizer (0, 50,100 and 150 kg $ha^{-1}$) arranged in a split-split plot and laid out in a randomized complete block design (RCBD). Sesame varieties occupied the main plots, tillage practices sub-plots and fertilizer rates sub-sub plots which gave 36 treatments 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 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 ridges produced higher yields followed by flat beds and then zero tillage in both cropping seasons. Sesame yield increased with increase in fertilizer rates up to 150 kg $ha^{-1}$. The effects of variety on soil properties did not differ significantly however, the improved varieties left lower essential nutrients in soil. Zero tillage retained higher nutrients and organic matter in soil while ridges gave lower values for essential nutrients and organic matter. Fertilizer application at 150 kg $ha^{-1}$ of NPK 15:15:15 favoured the retention of organic matter in soil as well as other essential nutrient elements. It can be recommended that sesame should be grown on ridges for sustainable production. For conservation/ retention of essential nutrients and organic matter in soil, zero tillage is recommended. Application of 150 kg $ha^{-1}$ of NPK 15:15:15 to sesame fields is hereby recommended for increase in yield and maintenance of soil fertility.

## 1.0 Introduction

Sesame (*Sesamum indicum* L.), otherwise known as benniseed belongs to the family *Pedaliaceae* and is one of the most ancient oilseed crops known to mankind (Langham *et al.,* 2008). Since its introduction to Nigeria after the Second World War, it has been regarded as a crop of insignificant importance compared to groundnut and other cash crops. Sesame is cultivated in almost all tropical and subtropical Asian and African countries for its highly nutritious and edible seeds (Iwo *et al.*, 2002).

Sesame is widely cultivated in the Northern and Central part of Nigeria. The major states involved in its production are: Adamawa, FCT Abuja, Benue, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Kogi, Nasarawa, Plateau, Taraba and Yobe (USAID, 2002; Iorlamen *et al.,* 2014). The sesame seeds serve as ingredients in soup and a source of oil

(43 %) (Biswas *et al.,* 2001). 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). The demand for sesame and its products is growing both at the National and International levels. Thus huge market potential exists for sesame. 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 practices have been reported to have a significant impact on sesame production especially through the improvement of soil properties with attendant provision of a suitable seedbed for good seed germination, easy emergence and good establishment of seedling by way of enhanced root growth thereby encouraging vertical and horizontal proliferation of roots through reduction in soil strength (Okeleye and Oyekanmi, 2003; Alam *et al.,* 2014; Ali *et al.,* 2006).

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).

Survey reports by various researchers in Nigeria revealed that farmers in savanna areas have no definite fertilizer recommendation for sesame as a sole crop as it is grown in mixture with other crops mostly cereals (Idowu *et al.,* 2002; Olowe, 2004; Ugbani *et al.,* 2008). In Nigeria also, there is no adequate information on the appropriate tillage practices for this crop in the agro-ecological zones. In order to increase the production of sesame, there is need for adoption of improved tillage practices as well as sound fertilizer recommendations that would ensure optimum yield. Therefore, the objective of the study was to determine the effects of tillage and fertilizer on soil properties and yield of sesame varieties with a view to identify appropriate tillage practice (s) and fertilizer rate that will give optimal yield of sesame in the study area.

## 2.0 Materials and Methods

### *2.1 Experimental Site*

Field experiments were undertaken during 2018 and 2019 cropping seasons at the Teaching and Research Farm, Federal University of Agriculture, Makurdi-Nigeria. The study 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 $^0$C. It is located between latitude 7$^0$41' N to 7$^0$42' N and longitude 8$^0$37' E to 8$^0$38' E.

The trial consisted of three factors. Sesame varieties at three levels (Jigida, NCRIBEN-01M and NCRIBEN-032), tillage practices at three levels (zero tillage, flat bed and ridges) and fertilizer rates at four levels (0, 50, 100 and 150 kg ha$^{-1}$ of NPK 15:15:15) and were laid out in a split-split plot in a RCBD with sesame varieties occupying the main plots, tillage practices sub-plots and fertilizer rates sub-sub plots which gave 36 treatments that were replicated thrice giving a total of 108 treatment combinations. Each plot measured 4 x 4 m (16 m$^2$) with an alley of 1 m as block boundaries and 0.5 m as plot borders giving a total land area of (41 m x 53.5 m) 2193.5 m$^2$ or 0.22 ha.

### *2.2 Land Preparation and Planting*

The experimental area was 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.

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.

### *2.3 Cultural Practices*

Two hoe weedings 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.

### *2.4 Harvesting*

Crop harvested from the net plots were used for grain yield determination. 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.

### *2.5 Soil Data Collection and Analysis*

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. 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 Advanced Soil Science Laboratory of the Federal University of Agriculture, Makurdi. 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 $CaCl_2$. 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 $NH_4OAC$ 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.

### *2.6 Crop Data Collection and Analysis*

Data were collected for the yield parameters of sesame for both cropping seasons 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.

## 3.0 Results and Discussion

### *3.1 Physical and Chemical Properties of the Experimental Site before Planting*

Selected physical and chemical properties of the experimental site before planting are shown on Table 1. The results indicated that soils for both cropping seasons were sandy loam in texture. 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 2018 and 2019 respectively (71.8 and 75.50 %) 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; Adamu *et al.,* 2010).

The slightly acidic pH of the soils (6.08 – 6.05) also indicate 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 this soil 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 with the exception of sodium 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 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.

Table 1: Selected Physical and Chemical Properties of the Experimental Site before Planting in Makurdi

| Property | 2018 | 2019 |
|---|---|---|
| Chemical Property | | |
| pH | 6.08 | 6.50 |
| Organic Carbon (%) | 0.52 | 0.53 |
| Organic Matter (%) | 0.90 | 0.91 |
| Total Nitrogen (%) | 0.11 | 0.12 |
| Available P ($mgkg^{-1}$) | 3.90 | 4.35 |
| Exchangeable Cation (Cmol $kg^{-1}$) | | |
| Ca | 3.00 | 2.30 |
| Mg | 2.80 | 2.10 |
| K | 0.27 | 0.31 |
| Na | 0.24 | 0.20 |
| EB | 6.31 | 4.91 |
| EA | 1.10 | 0.90 |
| CEC | 7.41 | 5.81 |
| Base Saturation (%) | 85.20 | 84.51 |
| Particle Size Distribution | | |
| Sand (%) | 71.8 | 75.50 |
| Silt (%) | 10.00 | 9.50 |
| Clay (%) | 18.20 | 15.00 |
| Textural Class | Sandy loam | Sandy loam |

### *3.2 Main Effects of Variety, Tillage and Fertilizer on the Yield of Sesame*

The main effects of the sesame variety, tillage practices 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 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. Number of capsules and yield of the crop were higher in the improved varieties (NCRIBEN-01M and NCRIBEN-032) than the local variety. NCRIBEN-032 gave significantly higher yield than the other varieties in 2018 and 2019 cropping seasons.

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).

The variability in yield and yield attributes as influenced by tillage practices in both seasons (Table 2) 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, results indicated that the performances of the varieties were largely influenced by the type of tillage practice they were grown on. Zero tilled soils gave the least yield of all the tillage practices in both cropping seasons. 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 2: Main Effects of Variety, Tillage and Fertilizer on the Yield of Sesame in Makurdi

| 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 $ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 |
| V1 | 3.01 | 2.99 | 13.92 | 14.47 | 48.42 | 68 | 337.4 | 370.1 | 137.19 | 135.42 | 0.34 | 0.43 |
| V2 | 3.03 | 3.01 | 17.89 | 14.67 | 59.58 | 67 | 379.9 | 372.0 | 136.94 | 138.81 | 0.54 | 0.44 |
| V3 | 3.03 | 3.02 | 24.11 | 14.92 | 54.94 | 228 | 382.5 | 375.0 | 139.69 | 140.67 | 0.48 | 0.44 |
| LSD ($P\leq0.05$) | NS | 0.034 | 3.20 | 0.93 | NS | NS | 17.19 | 6.32 | NS | 5.023 | 0.10 | NS |
| Tillage | | | | | | | | | | | | |
| Flat | 3.98 | 2.98 | 18.64 | 14.06 | 54.42 | 67 | 381.3 | 363.9 | 133.17 | 133.06 | 0.43 | 0.45 |
| Ridged | 3.03 | 3.00 | 23.81 | 14.67 | 55.39 | 68 | 387.6 | 372.1 | 138.53 | 138.89 | 0.45 | 0.48 |
| Zero | 2.98 | 3.05 | 14.47 | 15.33 | 57.14 | 229 | 371.8 | 381.1 | 122.14 | 142.94 | 0.42 | 0.40 |
| LSD ($P\leq0.05$) | NS | 0.029 | 4.21 | 0.80 | 1.27 | NS | 7.47 | 5.48 | 3.90 | 4.350 | 0.014 | 0.014 |
| Fertilizer | | | | | | | | | | | | |
| F1 | 2.90 | 2.88 | 12.41 | 12.48 | 50.37 | 62 | 348.3 | 344.4 | 122.96 | 121.81 | 0.38 | 0.38 |
| F2 | 3.06 | 2.99 | 13.11 | 13.59 | 54.48 | 66 | 361.8 | 361.3 | 133.93 | 133.67 | 0.43 | 0.43 |
| F3 | 2.99 | 3.02 | 14.04 | 15.11 | 57.11 | 69 | 389.1 | 377.8 | 143.81 | 142.37 | 0.44 | 0.45 |
| F4 | 3.16 | 3.15 | 16.33 | 17.56 | 60.63 | 288 | 420.5 | 405.9 | 151.07 | 155.33 | 0.49 | 0.49 |
| LSD ($P\leq0.05$) | 0.0345 | NS | 0.84 | NS | 1.47 | NS | 8.63 | NS | 4.62 | NS | 0.0162 | 0.10 |

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 zero tilled plots having the least yield for both years (0.42 and 0.44 t $ha^{-1}$) 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. 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.

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. 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 beds.

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 Babeji *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 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 nutrient 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; Brady and Weil, 2014). 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 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 number of leaves of sesame when inorganic fertilizer was used in 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 source 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 300kg $ha^{-1}$ 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 300kg $ha^{-1}$ and 200kg $ha^{-1}$ in 2009 and 2010 respectively.

### *3.3 Main Effects of Variety, Tillage and Fertilizer on Soil Properties*

The main effects of variety, tillage and fertilizer on selected soil properties are presented on Table 3a-c. The varieties did not have significant difference in their effect on most of the soil properties after harvest in 2018 and 2019. The effects of tillage on soil properties also show no significant difference in most of the parameters studied. The effects of fertilizer levels show that no significant differences were observed in most parameters studied though, most soil parameters increased with increasing levels of fertilizer application.

Tillage operations are known to influence both the release and conservation of soil nutrients. The effects of tillage practices on nutrients 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 as well (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; Powlson *et al.,* 2012; Schjonning and Tomsen, 2013). 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, tillage and organic matter in the soil and improves the availability of nutrients for plant growth through the formation of clay humus complexes and the increase of charged surfaces for nutrient binding. Accumulation of considerable amounts of total nitrogen, phosphorus (P), and potassium with conservation tillage was observed (Calegari *et al.,* 2013; Spiegel *et al.,* 2007). 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.

Table 3a: Main Effects of Variety, Tillage and Fertilizer on Selected Soil Properties in Makurdi

| Variety | BS (%) | | CEC (cmol kg$^{-1}$) | | Ca (cmol kg$^{-1}$) | | EA (cmol kg$^{-1}$) | | EB (cmol kg$^{-1}$) | | K (cmol kg$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 |
| V1 | 85.26 | 84.26 | 7.81 | 7.74 | 3.14 | 3.13 | 1.15 | 1.22 | 6.63 | 6.52 | 0.28 | 0.28 |
| V2 | 85.38 | 84.28 | 7.86 | 7.61 | 3.14 | 3.07 | 1.15 | 1.19 | 6.71 | 6.41 | 0.30 | 0.28 |
| V3 | 85.33 | 84.20 | 7.73 | 7.74 | 3.07 | 3.14 | 1.13 | 1.22 | 6.60 | 6.52 | 0.27 | 0.29 |
| LSD (P≤0.05) | 0.73 | NS | 0.49 | NS | 0.30 | NS | NS | NS | NS | NS | NS | NS |
| Tillage | | | | | | | | | | | | |
| Flat | 85.42 | 84.02 | 7.86 | 7.61 | 3.14 | 3.07 | 1.15 | 1.21 | 6.72 | 6.39 | 0.28 | 0.29 |
| Ridged | 85.32 | 84.41 | 7.78 | 7.84 | 3.10 | 3.17 | 1.14 | 1.22 | 6.64 | 6.62 | 0.28 | 0.28 |
| Zero | 85.23 | 84.31 | 7.75 | 7.64 | 3.11 | 3.08 | 1.14 | 1.20 | 6.58 | 6.44 | 0.29 | 0.28 |
| LSD (P≤0.05) | 0.73 | NS | 0.49 | NS | 0.30 | NS | NS | NS | NS | NS | NS | NS |
| Ferti-lizer | | | | | | | | | | | | |
| F1 | 84.77 | 83.79 | 7.55 | 7.26 | 3.00 | 2.88 | 1.15 | 1.18 | 6.40 | 6.08 | 0.26 | 0.22 |
| F2 | 85.05 | 83.98 | 7.51 | 7.77 | 2.99 | 3.21 | 1.12 | 1.24 | 6.35 | 6.52 | 0.26 | 0.25 |
| F3 | 85.90 | 84.28 | 8.02 | 7.66 | 3.19 | 3.05 | 1.13 | 1.20 | 6.89 | 6.46 | 0.29 | 0.32 |
| F4 | 85.57 | 84.95 | 8.12 | 8.09 | 3.27 | 3.28 | 1.17 | 1.22 | 6.95 | 6.87 | 0.33 | 0.34 |
| LSD (P≤0.05) | 0.84 | NS | 0.57 | 0.49 | 0.35 | 0.30 | NS | NS | 0.34 | 0.51 | 0.034 | 0.02 |

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 3b: Main Effects of Variety, Tillage and Fertilizer on Selected Soil Properties in Makurdi

| Variety | Mg (cmol kg$^{-1}$) | | N (%) | | Na (cmol kg$^{-1}$) | | OC (%) | | OM (%) | | P (mg kg$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 |
| V1 | 2.99 | 2.87 | 0.077 | 0.077 | 0.33 | 0.24 | 0.75 | 0.62 | 1.29 | 1.07 | 3.25 | 3.64 |
| V2 | 3.03 | 2.83 | 0.082 | 0.073 | 0.48 | 0.24 | 0.76 | 0.57 | 1.31 | 0.98 | 3.34 | 3.55 |
| V3 | 3.02 | 2.87 | 0.080 | 0.077 | 0.39 | 0.24 | 0.69 | 0.62 | 1.18 | 1.06 | 3.19 | 3.69 |
| LSD (P≤0.05) | NS | NS | 0.02 | NS | NS | NS | 0.06 | NS | NS | NS | 0.12 | NS |
| Tillage | | | | | | | | | | | | |
| Flat | 3.06 | 2.81 | 0.079 | 0.075 | 0.47 | 0.23 | 0.71 | 0.56 | 1.23 | 0.97 | 3.22 | 3.64 |
| Ridged | 2.97 | 2.93 | 0.076 | 0.075 | 0.48 | 0.24 | 0.70 | 0.70 | 1.21 | 1.21 | 3.31 | 3.76 |
| Zero | 3.01 | 2.84 | 0.081 | 0.076 | 0.25 | 0.24 | 0.78 | 0.55 | 1.34 | 0.94 | 3.25 | 3.49 |
| LSD (P≤0.05) | NS | NS | NS | NS | 0.08 | NS | 0.06 | 0.05 | 0.15 | 0.11 | NS | NS |
| Ferti-lizer | | | | | | | | | | | | |
| F1 | 2.90 | 2.77 | 0.073 | 0.053 | 0.24 | 0.21 | 0.61 | 0.66 | 1.05 | 1.14 | 3.44 | 2.50 |
| F2 | 2.89 | 2.84 | 0.074 | 0.063 | 0.34 | 0.23 | 0.69 | 0.43 | 1.18 | 0.75 | 3.19 | 3.45 |
| F3 | 3.16 | 2.84 | 0.083 | 0.087 | 0.56 | 0.24 | 0.80 | 0.55 | 1.38 | 0.95 | 3.68 | 3.85 |
| F4 | 3.09 | 2.97 | 0.085 | 0.099 | 0.46 | 0.27 | 0.83 | 0.76 | 1.43 | 1.32 | 2.74 | 4.72 |
| LSD (P≤0.05) | NS | NS | 0.008 | 0.005 | 0.12 | 0.03 | 0.11 | 0.06 | 0.14 | 0.13 | 0.25 | 0.41 |

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 3c: Main Effects of Variety, Tillage and Fertilizer on Selected Soil Properties in Makurdi**

| Variety | pH | | Sand (%) | | Clay (%) | | Silt (%) | |
|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 |
| V1 | 6.13 | 6.32 | 69.16 | 69.48 | 19.08 | 18.99 | 11.76 | 11.81 |
| V2 | 6.15 | 6.30 | 68.47 | 69.30 | 19.41 | 18.56 | 12.12 | 12.14 |
| V3 | 6.14 | 6.32 | 68.68 | 69.23 | 18.70 | 18.69 | 12.51 | 12.08 |
| LSD (P≤0.05) | NS | NS | NS | NS | NS | NS | NS | NS |
| Tillage | | | | | | | | |
| Flat | 6.14 | 6.30 | 68.94 | 70.00 | 19.00 | 18.19 | 12.04 | 12.08 |
| Ridged | 6.13 | 6.34 | 68.72 | 68.38 | 18.92 | 19.84 | 12.00 | 11.78 |
| Zero | 6.15 | 6.30 | 68.65 | 69.64 | 19.28 | 18.20 | 12.35 | 12.16 |
| LSD (P≤0.05) | NS | NS | NS | NS | NS | 0.67 | NS | NS |
| Fertilizer | | | | | | | | |
| F1 | 6.07 | 6.57 | 68.46 | 69.18 | 19.28 | 19.82 | 12.11 | 11.00 |
| F2 | 6.18 | 6.18 | 69.46 | 69.56 | 17.61 | 17.96 | 12.92 | 12.48 |
| F3 | 6.10 | 6.29 | 67.59 | 70.49 | 20.89 | 16.98 | 11.52 | 12.90 |
| F4 | 6.21 | 6.23 | 69.56 | 68.13 | 18.48 | 20.22 | 11.96 | 11.65 |
| LSD (P≤0.05) | NS | 0.18 | NS | NS | 0.14 | 0.77 | 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

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 (Phiri *et al.,* 2001).

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 suitable for soil health and achieving optimum yield of crops.

The effects of fertilizer applications on soil physical and chemical properties are importance to agricultural sustainability and to increase crop yield (Ayoola, 2006; Oloworeke, 2014). 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 very high degree of correlation with crop production and have high influence on soil fertility and crop performance (Adeniyan, 2008; Nnaji, 2009 and 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 nutrient 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 (Agbede, 2006; 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).

## 4.0 Conclusion and Recommendations

Based on the findings of this study, the ridges produced higher yields followed by flat beds and then zero tillage in both seasons. Sesame yield increased with increase in fertilizer rates up to 150 kg ha$^{-1}$ though, improved varieties performed better than the local variety in terms of yield. The effects of variety on soil properties did not differ significantly however, the improved varieties left lower essential nutrients in soil. Zero tillage retained higher nutrients and organic matter in soil while ridges gave lower values for essential nutrients and organic matter. Fertilizer application at 150 kg ha$^{-1}$ of NPK 15:15:15 favoured the retention of organic matter in soil as well as other essential nutrient elements. It can be recommended that sesame should be grown on ridges. For conservation/retention of essential nutrients and organic matter in soil, zero tillage is recommended. Application of 150 kg ha$^{-1}$ of NPK 15:15:15 to sesame fields is hereby recommended for increase in yield and maintenance of soil fertility.

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