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Effect of Tillage Practices on Selected Soil Properties in Makurdi, Southern Guinea Savanna Zone of Nigeria

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Abstract

A study was conducted in 2018 and 2019 cropping seasons to evaluate tillage practices' effect on soil properties at the Teaching and Research Farm, Federal University of Agriculture, Makurdi-Nigeria. Treatments consisted of zero tillage, flatbeds and ridges, and were laid out in a randomized complete block design (RCBD) and replicated three times. Before the experiment, surface (0-15 cm) soil samples were collected from eight points and bulked; post-harvest composite soil samples were also collected based on treatments and were analyzed using standard analytical procedures.NCRIBEN-032 variety of sesame was used as the test crop for both cropping seasons. 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. Based on the study's findings, there were significant effects of tillage practices to most soil parameters studied in the 2018 and 2019 cropping seasons. The effects of tillage practices on soil nutrients indicated that the zero tilled plots had higher nutrients and organic matter, followed by the flatbeds while the ridged plots gave lower values for essential nutrients and organic matter in both cropping seasons. For conservation/retention of essential nutrients and organic matter in the soil, zero tillage is recommended in the study area.

Keywords: Tillage practices, Soil properties, Southern Guinea Savanna, Nigeria

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1.0. Introduction

Tillage operations in various forms have been practiced from growing crop plants (Sharma and Behera, 2008). To prepare a virgin or fallow land and use it for growing crops, tillage in any form is an indispensable practice even today. Tillage is one of the forms of soil, water, nutrient, crop, and pests. Tillage helps to replace natural vegetation with useful crops and is necessary to provide a favorable edaphic environment for establishing, growth, and yield of crop plants (Sharma *et al.,* 2002). After the harvest of the crop, the soil becomes hard and compact. Beating raindrops, irrigation, and subsequent drying, movement of inter-cultivation implements, and labour cause soil compaction. Seeds need loose, friable soil with sufficient air and water for good germination. The field should be free from weeds to avoid competition with the crop. It should also be free from stubbles to facilitate easy and smooth movement of sowing implements.

Tillage practices have been reported to have a significant impact on crop production primarily through the improvement of soil properties with the 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 the vertical and horizontal proliferation of roots through a reduction in soil strength (Okeleye and Oyekanmi, 2003; Alam *et al.,* 2014; Ali *et al.,* 2006).

In Nigeria, farmers commonly till the soil improve its physical, chemical, and biological characteristics that alter plant growth and yield (Agber *et al.,* 2017). Crops grown without tillage are stunted and show water and nutrient deficiencies because of high surface bulk density, low porosity, retarded infiltration, and low water holding capacity of the soil (Ali *et al.,* 2015). However, conventional and traditional tillage methods negatively affect soil life and increase organic matter's mineralization. a zero tillage system 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).

Soil properties describe the physical and chemical characteristic behavior of soils, including the nutrient status (Usman, 2017). The need for basic knowledge and assessment of soil properties changes and fertility status to evaluate the impact of various tillage practices has become necessary for sustainable agriculture in Nigerian savanna zones. Similarly, for sustainable soil nutrient management in these zones, there is also a need to understand how soil responds to tillage practices over time (Oyedele *et al.,* 2014). One of the significant essential components of agricultural management and sustainability is that most farmers in the tropics maintain soil nutrients and qualities. This, according to Mallo (2010), provides an avenue for measuring levels of crop productivity. Soil properties reveal soil quality which measures the levels of soil fertility. This means that assessing soil quality also involves measuring and evaluating soil properties for optimum crop yield. Soil properties may influence various processes suitable for agricultural practices, though the dynamic soil nature describes the condition of a specific soil due to management practices. However, for sustainable crop production, there is a need to adopt improved tillage practices, and proper soil management practices that would ensure optimum crop yield. The knowledge of tillage and soil properties in Nigerian savanna is necessary to address low fertility status and ensure optimum food production. Thus, this study objective was to evaluate the effect of tillage practices on post-harvest soil properties of sesame fields in the study area.

2.0. Materials and methods

2.1 Experimental Site

A study was conducted in 2018 and 2019 cropping seasons to evaluate tillage practices effect on soil properties 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 a mean rainfall of about 1, 250 mm per annum, and 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.Treatments consisted of zero tillage, flatbeds, and ridges, and was laid out in anRCBD and replicated three times.NCRIBEN-032 variety of sesame was used as the test crop for both years.

2.2 Soil Data Collection and Analysis

Beforethe experiment, surface (0-15 cm) soil samples were collected from eight points and bulked; post-harvest composite soil samples were also collected based on treatments. The soil samples taken from each plot according to treatment were air-dried; crushed and sieved using a 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 a flame photometer, while Ca and Mg were 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.

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.

3.0. Results and Discussion

3.1 Physical and Chemical Properties of the Experimental Site

The selected physical and chemical properties of the experimental site are shown in Table 1. The results indicated that soils for both cropping seasons were sandy loam in texture. This texture is ideal for crop production as crop require soils that are well-drained for optimum growth and yield. The high sand content of the soils (71.8 and 75.50 %)for 2018 and 2019 respectively 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). The soil's slightly acidic pH (6.08 – 6.05) also indicates that the soils are suitable for crop production as this pH range is the optimum pH for most crops and microbial activities in soil.

The soils were low in essential plant nutrients and organic carbon except for sodium, which was moderate compared with soil fertility ratings by Esu (1991). This soil's low nutrient status is characteristic of many tropical soils where the slash and burn practice coupled with high insolation and rainfall prevents the buildup 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's soils are deficient in most nutrients.

3.2 Main Effect of Tillage Practices on Selected Soil Properties

The main effects of tillage practices on selected soil properties are presented in Table 2a-c. The effects of tillage practices on soil properties show no significant difference in most of the soil parameters studied apart from BS, CEC, and Ca in 2018, OC, and OM in 2019. 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 flatbeds while the ridged plots had the least available in both years. The higher nutrient status of zero tillage can be attributed to mulch's presence on the surface due to decomposed plant residues, which led to enhanced soil organic matter status and the 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 result 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 topsoil layer (Bronick and Lal, 2005; Vogeler *et al.,* 2009; Powlson *et al.,* 2012; Schjonning and Tomsen, 2013). In general, tillage improves crop residues decomposition by facilitating contact between plant tissue and soil aggregate surfaces, the primary biome of soil microorganisms (Bronick and Lal, 2005). Also, tillage and organic matter in the soil improve the availability of nutrients for plant growth through the formation of clay humus complexes and the increase of charged surfaces for nutrient binding.

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

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 because the land was not disturbed, which increased the buildup of soil organic matter, resulting in high organic carbon, reflecting 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 have been reported to have increased in organic C content, which enhances soil quality and resilience (Abid and Lal, 2008). Differences in available N among tillage systems observed in the current study agree 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 2a: Main Effects of Tillage Practices on Selected Soil Properties in Makurdi

	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
Tillage Practices												
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 ($P \leq 0.05$)	0.73	0.32	0.49	NS	0.30	0.11	NS	NS	0.13	0.22	NS	NS

NS= Not significant

Table 2b: Main Effect of Tillage Practices on selected Soil Properties in Makurdi

	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
Tillage Practices												
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 ($P \leq 0.05$)	0.89	0.16	0.012	NS	0.08	NS	0.06	0.05	0.15	0.11	0.13	0.17

NS= Not significant

Table 2c: Main Effect of tillage Practices on selected Soil Properties in Makurdi

	pH		Sand (%)		Clay (%)		Silt (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
Tillage Practices								
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 ($P \leq 0.05$)	NS	NS	0.55	0.86	0.62	0.67	NS	0.77

Similarly, in 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 and 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, 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 than 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 topsoil 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 positively affected soil properties and crop yields. Bulk and particle 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 suitable for soil health and achieving an optimum yield of crops.

4.0. Conclusion and Recommendations

Based on this study's findings, there were significant effects of tillage practices for most soil parameters studied in the 2018 and 2019 cropping seasons. The effects of tillage practices on soil nutrients indicated that the zero tilled plots had higher nutrients and organic matter, followed by the flatbeds while the ridged plots gave lower values for essential nutrients and organic matter in both cropping seasons. For conservation/retention of essential nutrients and organic matter in the soil, zero tillage is recommended in the study area.

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