Effect of Tillage Practices on Selected Soil Properties in Sudan Savanna Agro-Ecology of Nigeria

Usman, M.[1*], Ali, A.[2], Agber, P.I.[3]

[*1]Department of Agricultural Science Education, Federal College of Education (Technical), Potiskum-Nigeria
[2,3]Department of Soil Science, Federal University of Agriculture, Makurdi-Nigeria
*Corresponding Author's

Received: 27 January 2021/ Revised: 8 February 2021/ Accepted: 14 February 2021/ Published: 28-02-2021

Abstract— *Field experiments were carried out in 2018 and 2019 cropping seasons to evaluate the effect of tillage practices on selected soil properties in Sudan Savanna Agro-ecology of Nigeria. Treatments consisted of zero tillage, flat beds and ridges, and were laid out in a randomized complete block design (RCBD) and replicated three times. Prior to experiment, 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 and were analyzed using standard analytical procedures. NCRIBEN-01M 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 findings of this study, there were significant effects of tillage practices with respect to most soil parameters studied in 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 flat beds while the ridged plots gave lower values for essential nutrients and organic matter in both cropping seasons. For conservation or retention of essential nutrients as well as organic matter in soil, zero tillage is recommended for the study area*.

Keywords— ***Soil properties, Sudan Savanna, Tillage Practices, Nigeria.***

I. INTRODUCTION

Tillage is performed to loosen the soil and produce a good tilth. Tillage requirement of a crop is site, environment and soil type specific (Ojeniyi and Agboola, 1995). Tillage contributes up to 20 % amongst crop production factors (Adekiya and Ojeniyi, 2011). Tillage operations in various forms have been practiced from the very inception of 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 management practices of soil, water, nutrient, crop and pests. Tillage helps to replace natural vegetation with useful crops and is necessary to provide a favourable edaphic environment for the establishment, growth and yield of crop plants (Sharma *et al.*, 2002). After harvest of the crop, soil becomes hard and compact. Beating action of rain drops, 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. There have been conflicting reports on the influence of tillage on soil chemical properties; likewise contradictory reports as to the superiority of crops on tilled plots to those of no-till plots have been documented (Adekiya and Ojeniyi, 2011). Ridge tillage was found to increase growth of okra on ultisol of central Southwest, Nigeria relative to no-tillage (Ojeniyi and Adekayode, 1999).

However, manual tillage systems including ridges, heaps and flat beds have been reported to degrade soil quality and reduce chemical and biological qualities especially on alfisols in the rainforest areas of Southwest, Nigeria (Busari and Salako, 2013). The study of relative effect of ridging and no-tillage on soil properties and yield of sweet potato in guinea savanna zone (middle belt) of Nigeria showed that no-till gave higher tuber yield of sweet potato compared to ridging, which was adduced to have higher moisture content, N, P, K, Ca and Mg status (Ojeniyi, 1993). 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 grown without tillage are stunted and show symptoms of 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, 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 hand, 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 behaviour of soils including the nutrient status (Usman, 2017). The need for basic knowledge and assessment of changes in soil properties and their fertility status with time 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 need for an understanding of how soil responds to tillage practices over time (Oyedele *et al.*, 2014). One of the major important components of agricultural management and sustainability as well, a goal of most farmers in the tropics is the maintenance of soil nutrients and qualities. This according to Mallo (2010) provides 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 have influence on various processes that are 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 need for adoption of improved tillage practices and proper soil management that would ensure optimum crop yield. The knowledge of tillage and soil properties in Nigerian savanna is necessary in addressing the problem of low crop productivity and to ensure optimum food production. Thus, the objective of this study was to provide documented information on the effect of tillage practices on post harvest soil properties of sesame fields in the study area.

II. MATERIALS AND METHODS

2.1 Experimental Site

Field experiments were carried out in 2018 and 2019 cropping seasons to evaluate the effect of tillage practices on post harvest selected soil properties of sesame fields at the Research Farm of the Federal College of Education (Technical), Potiskum, Yobe State-Nigeria. NCRIBEN-01M variety of sesame was used as the test crop for both cropping seasons. Treatments consisted of zero tillage, flat beds and ridges, and were laid out in a RCBD and replicated three times. The study location falls within the Sudan Savanna Agro-ecology of Nigeria with mean rainfall of about 800 mm per annum and temperature of 39 – 42 ^{0}C. It is located between latitude $11^0$42' N to $11^0$43' N and longitude $11^0$04' E to $11^0$06' E (YSGN, 2008).

2.2 Soil Data Collection and Analysis

Prior to experiment, 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 Department of Soil Science, University of Maiduguri, 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 $CaCl_2$. 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. 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.

III. RESULTS AND DISCUSSION

3.1 Selected Soil Properties of the Experimental Site before Planting

The results of analysis of selected soil properties of the experimental site before planting are presented on Table 1. The results indicated that soils for both cropping seasons were sandy clay loam in texture. This texture is ideal for crop production as crops require soils that are well drained for optimum growth and yield. The high sand content of the soils in 2018 and 2019 respectively (67.10 – 65.00 %) was indicative of the low clay content (21.20 – 20.90 %) for both years 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 (Malgwi *et al.*, 2008). The slightly acidic pH of the soils (6.96 – 6.70) also indicate 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 results of physical and chemical properties of the experimental site before planting (Table 1) indicates a poor soil fertility status that requires fertilizer application to replenish nutrients taken out from the soil through crop harvest and to supplement nutrients to boost yields (Olatunji and Ayuba, 2012). The values of SOM (1.95 and 0.98 %) for the two cropping seasons were below the average range of 2.5- 2.6 % considered for good crop growth (Aduayi *et al.*, 2002) in the study area. The results of the soil analysis thus indicated that soil amendment was required in line with earlier observation by Agboola (1975) who reported that farmers in Africa requires adequate soil amendment for good crop production as a result of low inherent soil fertility. In addition, 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 (Aduayi *et al.* (2002; Anjembe, 2004; Senjobi *et al.* (2013).

TABLE 1
SELECTED SOIL PROPERTIES OF THE EXPERIMENTAL SITE BEFORE PLANTING IN POTISKUM

Property	2018	2019
Chemical Property		
pH	6.96	6.70
Organic Carbon (%)	0.55	0.57
Organic Matter (%)	1.95	0.98
Total Nitrogen (%)	0.17	0.19
Available P (mgkg^{-1})	3.15	3.30
Exchangeable Cation (Cmol kg^{-1})		
Ca	3.10	2.83
Mg	2.80	2.60
K	0.24	0.22
Na	0.03	0.02
EB	6.17	5.67
EA	0.20	0.18
CEC	6.37	5.85
Base Saturation (%)	96.86	96.92
Particle Size Distribution		
Sand (%)	67.10	65.00
Silt (%)	11.70	14.10
Clay (%)	21.20	20.90
Textural Class	Sandy clay loam	Sandy clay loam

3.2 Main Effect of Tillage Practices on Selected Soil Properties

The main effects of tillage practices on selected soil properties are presented on Table 2a-c. The effect of tillage practices on soil properties also show significant difference in most of the soil parameters studied in 2018 and 2019 cropping seasons. 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).

TABLE 2 a
MAIN EFFECT OF TILLAGE PRACTICES ON SELECTED SOIL PROPERTIES IN POTISKUM

Tillage Practices	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
Flat	88.17	91.76	6.40	6.48	3.54	3.57	0.47	0.52	5.93	5.96	0.27	0.34
Ridged	89.22	89.61	6.16	6.22	3.29	3.32	0.57	0.64	5.56	5.58	0.25	0.25
Zero	88.42	92.84	6.47	6.57	3.62	3.65	0.37	0.42	6.10	6.06	0.28	0.28
LSD ($P \leq 0.05$)	0.14	1.35	NS	0.19	0.22	0.16	0.08	0.05	0.39	0.32	NS	0.15

NS= Not Significant

TABLE 2 b
MAIN EFFECT OF TILLAGE PRACTICES ON SELECTED SOIL PROPERTIES IN POTISKUM

Tillage Practices	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
Flat	1.50	1.51	0.083	0.083	0.62	0.62	0.88	0.88	1.52	1.51	3.29	3.30
Ridged	1.45	1.45	0.079	0.085	0.57	0.57	0.86	0.86	1.49	1.48	3.91	3.92
Zero	1.83	1.56	0.083	0.079	0.64	0.64	0.89	0.89	1.54	1.54	3.30	3.32
LSD ($P \leq 0.05$)	0.22	NS	0.002	0.004	0.04	0.05	NS	0.12	NS	0.10	0.312	0.25

NS= Not Significant

TABLE 2 c
MAIN EFFECT OF TILLAGE PRACTICES ON SELECTED SOIL PROPERTIES IN POTISKUM

Tillage Practices	pH		Sand (%)		Clay (%)		Silt (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
Flat	6.57	6.62	71.78	71.73	15.07	15.07	13.15	13.20
Ridged	6.56	6.57	72.60	72.35	14.54	14.54	12.86	13.11
Zero	6.61	6.56	70.43	70.36	16.13	16.22	13.43	13.43
LSD ($P \leq 0.05$)	NS	NS	1.49	1.34	0.72	0.65	0.34	NS

NS= Not Significant

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.

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 suitable for soil health and achieving optimum crop yields.

IV. CONCLUSION AND RECOMMENDATIONS

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

REFERENCES

[1] Abid, M. and 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.

[2] Adekiya, A. O. and Ojeniyi, S. O. 2011. Soil physical properties and cocoyam performance as influenced by tillage on an alfisol in Southwest Nigerian. *Nigerian Journal of Soil Science*. 21:16-21.

[3] Adekiya, A. O., Agbede, T. M., Ojomo, A. O. 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.

[4] Aduayi, E. A., Chude, V. O., Adebusuyi, B. A. and Olayiwola, S. O. eds. 2002. Fertilizer Use and Management Practices for Crops in Nigeria. 3rd Garko international limited. 67-70.

[5] Agbede, T. M. 2008. Nutrient availability and cocoyam yield under different tillage practices. *Soil and Tillage Research* 99(1): 49–57.

[6] Agber, P. I., Akubo, J. Y. and Abagyeh, S. O. I. 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.

[7] Agboola, A. A. 1975. The problem of improving soil fertility by the use of green manure in tropical farming system. *FAO Soil Bulletin*. 27: 147-163.

[8] Alam, M. K., Islam, M. M., Salahin, N. and 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.

[9] Ali, A., Ayuba, S. A. and Ojeniyi, S. O. 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.

[10] Ali, A., Ibrahim, N. B. and 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.

[11] Anjembe, B. C. 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.

[12] Bouyocous, G.H. 1951. A Recalibration of the Hydrometer Method for making the Mechanical Analysis. *Agronomy Journal.* 43: 434-438.

[13] Bray, R. H. and Kurtz, L. T. 1945. Determination of total organic and available forms of phosphorus in soils. *Soil Science.* 59: 39-45.

[14] Bremner, J.M. and Mulraney, C.S. 1982. Nitrogen Total In: Methods of Soil Analysis 2nd ed. A.L. Page *et al*., (Eds) ASA, SSSA Medison Winsconsin. Pp. 595-624.

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

[16] Busari, M. A. and Salako, F. K. 2013. Effect of tillage, poultry manure and NPK fertilizer on soil chemical properties and maize yield on an alfisol at Abeokuta, Southwest Nigeria. *Nigerian Journal of Soil Science.* 23:206-218.

[17] Calegari, A. Tiecher, T. Hargrove, W. L. 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

[18] Ismail, I., Blevins, R. L. and Frye, W. W. 1994. Long-term no-tillage effects on soil properties and continuous corn yields. *Journal of Soil Science Society of America*. 58: 193-198.

[19] Malhi, S. S. Grant, C. A. Johnston, A. M. and Gill, K. S. 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.

[20] Mallo, I. I. Y. 2010. Effects of soil erosion and marginal land surfaces on rural farmlands at Shadalafiya and Gora, Kaduna State, Northern Nigeria. *International Journal of Agriculture and Rural Development* 1:169-182.

[21] Malgwi, W. B, Ojaguna, A. G Chude, V. O. Kparmwang, T. and Raji, B. A. 2008. Morphological and Physical Properties of some Soils at Samaru, Zaria, Nigeria. *Nigeria Journal of Soil Research,* 1: 58 – 64.

[22] Martin-Rueda, I. Munoz-Guerra, L. M. Yunta, F. Esteban, E. Tenorio, J. L. and Lucena, J. J. 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.

[23] Mrabet, R., Saber, N., El-Brahli, A. Lahlou, S. and 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. Nigeria. *Journal of Agric. Science and Technology.* 1:70-71.

[24] Ojeniyi, S. O. 1993. Nutrient availability and maize yield under reduced tillage practices. *Soil and Tillage Reseach* 26: 89-92.

[25] Ojeniyi, S. O. and Adekayode, F. O. 1999. Response of soil properties and crops to manual, mechanical and zero tillage. A paper presented at the symposium of Nigeria branch of International Soil Tillage Research Organization, on October 20- 24th, WCAM Ilorin.

[26] Ojeniyi, S. O. and Agboola A. A. 1995. A review of tillage requirements of food crops in African. *African Soils.* 28:255-266.

[27] Olatunji, O. and Ayuba, S. A 2012. Effect of combined applications of poultry manure and NPK 20-10-10 fertilizer on soil chemical properties and yield of maize (*Zea mays* L.). Proceedings of the 35th Annual Conference of the Soil Science Society of Nigeria (SSSN), 7th – 11th March, Federal University of Technology Minna-Nigeria.

[28] Oyedele, A. O., Denton, O. A., Olayungbo, A. A. and Ogunrewo, O. M. 2014. Spatial assessment of soil quality indicators under different agricultural land uses. *IOSR Journal of Agriculture and Veterinary Science (*IOSR-JAVS) 7(8):41-48.

[29] Powlson, D. S. Bhogal, A. Chambers, B. J. 2012. The potential to increase soil carbon stocks through reduced tillage or organic material additions in England and Wales: a case study, *Agricultural Ecosystem and Environment*, 146(1):23–33.

[30] Redel, Y. D. Rubio, R. Rouanet, J. L. and Borie, F. 2007. Phosphorus bioavailability affected by tillage and crop rotation on a Chilean volcanic derived Ultisol, *Geoderma*, 139 (3- 4):388–396.

[31] Saleque, M. A., Mahmud. M. N. H., Kharun, A., Haque, M. M., Hossain, A. T. M. S. and Zaman, S. K. 2009. Soil qualities of saline and non-saline deltas of Bangladesh. *Bangladesh Rice Journal,* 14 (1&2): 99- 11.

[32] Schjønning, P. and Tomsen, I. K. 2013. Shallow tillage effects on soil properties for temperate-region hard-setting soils, *Soil and Tillage Research*, 132:12–20.

[33] Senjobi, B. A., Ande, O. T. and Okulaja, A. E. 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.

[34] Sharma, A. R. and Behera, U. K. 2008. *Modern concepts of Agriculture: Conservation tillage.* Indian Agricultural Research Institute, New Delhi. Pp. 1-42.

[35] Sharma, R. K., Chhokar, R. S., Chauhan, D. S., Gathala, M. K., Kundu, V. R. and Pundir, A. K. (2002). *Rotary Tillage – A Better Resource Conservation Technology*.Bulletin No. 12, Directorate of Wheat Research, Karnal, Haryana.

[36] Spiegel, H. Dersch, G. H¨osch, J. and Baumgarten, A. 2007. Tillage effects on soil organic carbon and nutrient availability in a long-term field experiment in Austria, *Bodenkultur*, 58 (1):47–58.

[37] Usman, M. 2017. *Introductory Soil Science.* Zaria: Ahmadu Bello University Publishers. Pp. 22-23.

[38] Vogeler, I. Rogasik, J. Funder, U. Panten, K. and 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.

[39] Yin, X. H. and Vyn, T. J. 2002. Soybean responses to potassium placement and tillage alternatives following no till. *Agronomy Journal*, 94: 1367-1374.

[40] YSGN 2008. Yobe State Ministry of Information; 2008. Available: http://zodml.org/Nigeria/Geography/Yobe State/.

[41] Zibilske, L. M., Bradford, J. M. and Smart, J. R. 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.