International Journal of Science Academic Research
Vol. 03, Issue 01, pp.3408-3412, January, 2022
Available online at http://www.scienceijsar.com
ISSN: 2582-6425

Research Article

IMPACT OF TILLAGE PRACTICES ON SOIL PROPERTIES OF EMOHUA-RUMUJI SOILS, RIVERS STATE, NIGERIA

***Onwugbuta, Godpower Chukwuemeka and John, Godson Nnamdi**

Department of Biochemistry/Chemistry Technology, School of Science Laboratory Technology, University of Port Harcourt, India

Received 18th November 2021; **Accepted** 12th December 2021; **Published online** 30th January 2022

Abstract

The study was conducted to determine the effect of tillage practices on soil properties under maize cultivation in Rumuji in Emuoha, Rivers State, Nigeria. The tillage systems evaluated were traditional, mulch and No tillage systems. The results showed a significant difference in soil parameters and crop morphologies at $p < 0.05$ among the tillage systems. The traditional tillage system resulted to the most favorable soil environment, for crop growth and best performance of crop followed by conventional and no-tillage systems in the area studied respectively. The significant difference in yields adduced to lower bulk density, higher water holding capacity and porosity which increased plant root proliferation and optimal utilization of soil nutrients under tillage methods. Hence tillage methods have the capability to increase production, while no-tillage is better under long term production for sustainable landuse.

Keywords: Impact**,** Tillage, Soil, Cultivation

INTRODUCTION

The ever-increasing population scenario of Nigeria makes it a necessity for more land to be opened up and efficiently managed for increased food production. The Nigerian traditional tillage method involves the use of hoes to make mounds size of which depends on the crop to be grown on. This method is gradually being replaced by conventional method of plough and harrow. Considering the fragile nature of Nigeria savannah soils, this method has further impoverished the soils due to erosion, increased loss of soil moisture by evaporation and compaction. Appropriate tillage practices are those that avoid the degradation of soil properties but maintain crop yields as well as ecosystem stability. In recent years, the interest in conservation tillage systems has increased in response to the need to limit erosion and promote water conservation. This has been considered to provide the best opportunity for halting degradation and for restoring and improving soil productivity. Conservation tillage is being adopted by local farmers in order to protect the soils from adverse effects of climate. However, the effects of this method need to be examined further in savanna soils of Nigeria characterized with limited rainfall, high temperature and fragile soils prone to erosion (*Brady, 2002*). The aim of this work is to examine different tillage systems and how soil physicochemical properties and maize crop respond to different tillage strategies**.** Tillage is the agricultural preparation of soil by mechanical agitation of various types, such as digging, stirring, and overturning. Examples of powered tilling methods using hand tools include shoveling, picking, mattock work, hoeing, and raking. Examples of draft-animal-powered or mechanized work include plugging, rootling, rolling with cult packers or other rollers, harrowing, and cultivating with cultivator shanks. Tillage that is deeper and more thorough is classified as primary, and tillage that is shallower and sometimes more selective of location is secondary.

Corresponding Author:** ***Onwugbuta, Godpower Chukwuemeka
Department of Biochemistry/Chemistry Technology, School of Science Laboratory Technology, University of Port Harcourt, India.

Primary tillage such as plugging tends to produce a rough surface finish, whereas secondary tillage tends to produce a smoother surface finish, such as that required to make a good seedbed for many crops. Harrowing and rootling often combine primary and secondary tillage into one operation (*Mahdi Al-Kaisi, 2002)*. The potential benefits of no-till fallow, compared with other tillage systems, are more effective control of soil erosion, increased water storage, lower energy costs per unit of production and higher grain yields. A major disadvantage of no-till fallow (sometimes referred to as chemical fallow) is its heavy use of herbicides for weed control (Wang, 2002). Soil pH is a measure of the acidity or alkalinity of the soil. A pH value is actually a measure of hydrogen ion concentration. Because hydrogen ion concentration varies over a wide range, a logarithmic scale (pH) is used: for a pH decrease of 1, the acidity increases by a factor of 10. It is a 'reverse' scale in that a very acid soil has a low pH and a high hydrogen ion concentration. Therefore, at high (alkaline) pH values, the hydrogen ion concentration is low. Most soils have pH values between 3.5 and 10. In higher rainfall areas the natural pH of soils typically ranges from 5 to 7, while in drier areas the range is 6.5 to 9. Soils can be classified according to their pH value. Different soil management regimes such as abandonment, resulted in greater levels of soil microbial biomass than did Cropping, but similar levels of enzyme activity were observed under both regimes. The Fallow regime gave significantly lower soil organic carbon levels and enzyme activities than did Cropping. Within the Cropping system, the treatments containing nitrogen and phosphorus significantly improved Soil Organic Carbon, Nitrogen and Phosphorus levels and also increased microbial biomass and enzyme activity relative to the control. In general, the highest values of the tested soil parameters were observed under the M2NPK treatment. With the exception of inverters, the activity of all soil enzymes tested correlated significantly with SOC and microbial biomass. Some nitrogenous fertilizers such as ammonium nitrate and urea have a high mobility potential and may undergo leaching. Also, the excessive use of nitrogenous fertilizers in agriculture has resulted in losses in the form of their derivatives and leaching of fertilizers below the root zone that created problems by contaminating groundwater. Nitrate, passing through macro pores, which serve as flow passage for water, can move into the soil with the infiltrate water. The enhanced water movement through soil macro pores in the profile increases the potential of soluble nitrates movement under no tillage scenario (Ahmad *et al.,* 2009). Aikins and Afuakwa (2010) searched the factors which affect nitrate movement in soil profile; it included soil physical properties (especially soil texture and structure), irrigation water, soil type, method and time of nitrogen fertilizer application and the management practices. They further reported, after the experimentation, that favourable soil conditions and higher amount of nutrients availability to the plant does happen due to conventionally tilled soil and it may also lead to vigorous crop growth which is the result of rapid decomposition of organic source of N in deep soil layer. The effect of tillage practices particularly on N, for the crop production, is therefore critical for the production of sustainable crops. The integration practices including appropriate N management and tillage practices, for sustainable crop production, thus presents a significant challenge.

MATERIALS AND METHODS

Soil samples were collected at depths of 0–15cm and 0-30cm from each plot respectively at the end of maize cropping cycle in every year from Rumuji, Emuoha Local Government Area of Rivers State. Composite surface samples (0 – 15 cm) and sub-surface samples (15 – 30 cm) were taken at the lower slope of the top sequence selected for the research with the aid of a soil Auger using alder's method. These were later air-dried, crushed and sieved before taken to the laboratory for physical and chemical analyses of the soils. Three tillage operations were imposed on the soil. These were conventional (traditional tillage) and conventional (mulch tillage and no tillage) operations. The experiments were laid out in a randomized complete block design with three replicates.

Physicochemical Properties of the Soil

Soil analysis were carried out later to observe the variations in soil properties due to applied different tillage operations.

Particle Density

The dry, sieved soil sample was weighed and mixed with distilled water and then boiled to remove any air. The mixture was allowed to cool for a day after which water was added until the volume of the mixture was 100ml. The temperature and mass of final mixture was measured and the soil particle data sheet was used to calculate the soil particle density.

Soil pH

The determination of pH of the soil sample was carried out with a pH meter using meter method.

Procedure

The pH meter was calibrated with buffer 4 and 7 solution respectively after 15minutes stabilization period. The electrode was rinsed with distilled water and then dipped into the water samples and allowed to stabilize at 25% ^{0}C. 20g of each air dried ground and sieved soil samples were dissolved in 100ml of distilled water. The lump of soil was stirred to form homogeneous slurry, then the electrode was immersed into the sample and allowed to stabilize at 25^{0}C and pH was read. After each reading the electrode was cleaned and dropped in distilled water when the pH meter was not in use.

Exchangeable Cations

The exchangeable cations were extracted with neutral ammonium acetate solution; Ca and Mg were determined by atomic absorption spectrophotometer, and K and Na by flame photometer.

Total Nitrogen

This was determined by the semi micro-kjeldahl method. Nitrogen in the sample was converted to ammonium sulphate by digesting the sample with concentrated sulfuric acid in the presence of a catalyst mixture. The digest was distilled with sodium hydroxide and ammonia was liberated which was collected in 5% boric-acid mixed indicator solution and titrated with standard hydrochloric acid.

Soil Moisture Content

Determined using oven dry method

The sample bottle + lid was cleaned and dried then weighed to 0.01g (W1). The soil sample (10g) was placed in the weighing tin and the lid was replaced then weighed to 0.01g (W2) after which the lid was removed. The tin containing the soil sample and the lid was placed separately in the oven and dried to a constant weight between 105°C and 110°C thereafter, they were removed from the oven and the tin was replaced. The tin was placed in the desiccators to cool down after which it was weighed to 0.01g (W3).

Determination of Soil Organic Carbon by Titrimetric method

Soil samples were air-dried at room temperature. 0.1g of dried soil samples were weighed into a 100ml conical flask. 5ml of potassium dichromate K_2CrO_7 was added and 7.5ml of concentrated tetraoxosulphate (VI) acid was equally added. A blank solution without soil sample solution was prepared by adding same volume of $K_2CrO_7$and conc.H_2SO_4 to distilled water (this serves as reference sample). The conical flask was placed in a preheated block at 145-155 degrees centigrade and the flask was removed and allowed to cool. 5ml of the sample solution was titrated with 0.2M ferrous ammonium sulphate using Ferro in as indicator. The colour change is from greenish yellow to red end-point.

Soil Texture

Soil texture was determined using mechanical soil analysis.

Procedures

The soil samples were dried, particles greater than 2mm such as gravel and stones were removed. The remaining part of the sample which is the fine earth was ground to free separate particles and the total weight of the fine earth was recorded accurately. The fine earth was passed through a series of sieves with mesh of different sizes, down to 0.01mm in diameter. The weight of the content of each sieve was calculated separately and expressed as a percent of the total initial weight of the fine earth. The weight of the very small particles of silt and clay which was passed through the finest sieve was measured by sedimentation and they were also expressed as a percent of the total initial weight of the fine earth.

Soil Bulk Density

10g soil sample was weighed and recorded. The soil sample is then oven dried at 105°c and weighed, this results in the dry weight of the soil. The bulk density is estimated by dividing the dry weight of the soil material (Wd) by volume of soil (Vs).

Soil Porosity

The soil sample is transferred into a graduated beaker to get the volume of the soil (Vs). A generous amount of water is measured into a graduated cylinder and recorded. The soil sample is then saturated with water to the exact top of the soil in the beaker, the volume of water used is subtracted from the starting volume in the graduated cylinder, and this depicts how much water it takes to saturate a soil sample.

RESULTS AND DISCUSSION

Bulk and Particle densities

The results of this research indicate that at depths between 0-30cm, traditional tillage system has a better impact on bulk density of the soil. Traditional tillage system has a mean bulk density of 1.30g/cm^3 which is lower than that of mulch tillage system and No-tillage at all. A multiple comparison of the bulk densities of the tillage types revealed a significant difference between traditional tillage system and No-tillage, this implies that traditional tillage system is much effective in reducing the bulk density of soils. The results on particle density of the soils sampled indicate that traditional tillage system is more effective in reducing particle density of soils (2.4g/cm^3). A statistical analysis using multiple comparison (LSD) revealed a significant difference between the particle densities of traditional tillage system and No-tillage at depths of 0-15cm and 15-30cm for traditional tillage and No-tillage respectively. These are graphically illustrated in Figure (1).

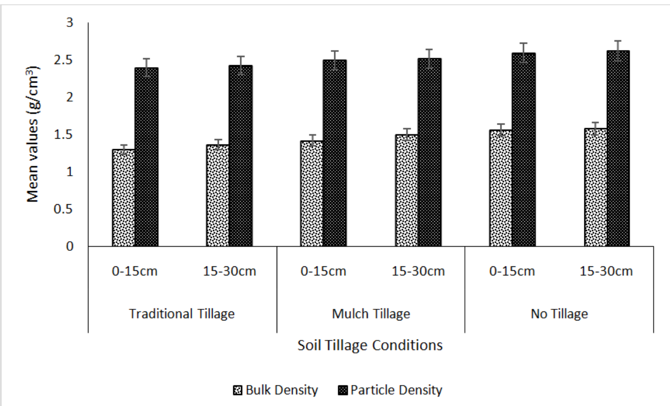

Fig. 1. Bulk and Particle densities of different soil tillage conditions

Porosity

The results on porosity revealed a statistically significant difference between all the tillage types and No-tillage. This is so across the depths of 0-15 and 15-30cm. From this result, it is clear that tillage systems do have an impact on the porosity of soils, but it was noted that mulch tillage system is more effective at increasing the soil's porosity (52.52% and 55.90%) at depths of 0-15cm and 15-30cm respectively. This is closely followed by traditional tillage system 48.22% and 53.90% at depths of 0-15cm and 15-30cm respectively.

Sand, Silt and Clay

The results on sand, silt and clay revealed a statistically significant difference between all the tillage types and No-tillage. This is so across the depths of 0-15 and 15-30cm. From these results, it is clear that all tillage systems do have an impact on the percentage of sand in the soil. However, traditional tillage system is much more effective with a mean sand percentage of 68.20% and 64.40% at the depths of 0-15cm and 15-30 cm respectively, which is lower than that of mulch tillage system and No-tillage at all. This implies that traditional tillage system is much effective in reducing the percentage of sand in the soil at the depths of 0-15cm and 15-30 cm respectively. This is graphically illustrated in Figure (2).

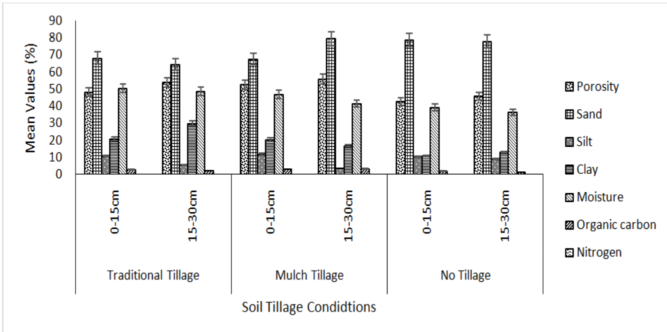

Fig. 2. Physicochemical properties of soil at different tillage conditions

From the results, it is clear that tillage systems do have an impact on the percentage of silt in the soil. However, No-tillage system is much more effective with a mean silt percentage of 10.40% and 9.00% at the depth of 0-15cm and 15-30 cm respectively, which is higher than that of mulch and traditional tillage. This implies that No-tillage is much effective in increasing the silt percentage of sand in the soil at the depth of 0-15cm and 15-30 cm, respectively. However, traditional tillage system is much more effective with a mean clay percentage of 21.00% and 30.00% at the depths of 0-15cm and 15-30 cm, respectively which is higher than that of mulch tillage and No-tillage. This implies that traditional tillage is much effective in increasing the clay percentage of sand in the soil at the depth of 0-15cm and 15-30 cm respectively.

Moisture Content

The results on moisture content reveal a statistically significant difference between all the tillage types and No-tillage using multiple comparison (LSD), this is so across the depths of 0-15 and 15-30cm. It is clear that tillage systems do have an impact on the moisture content of soils, but it was noted that traditional tillage system is more effective at increasing the soil's moisture content (50.40% and 48.70%) at depths of 0-15cm and 15-30cm respectively. This is closely followed by mulch tillage system 46.82% and 41.40% at depths of 0-15cm and 15-30cm respectively.

Organic Carbon

The results on organic carbon show a statistically significant difference between all the tillage types and No-tillage. This is so across the depths of 0-15 and 15-30cm. From these results, it is clear that tillage systems do have an impact on the organic carbon of soils, but it was noted that mulch tillage system is more effective at increasing the soil's organic carbon (3.54% and 3.31%) at depths of 0-15cm and 15-30cm respectively. This is closely followed by traditional tillage system 3.03% and 2.62% at depths of 0-15cm and 15-30cm respectively.

Total Nitrogen

From Table 4.2, the results on total nitrogen shows no statistical significant difference between all the tillage types and no tillage. This is so across the depths of 0-15 and 15-30cm. From these results, it is clear that tillage systems do not have an impact on the total nitrogen of soils.

Exchangeable Cations (Na^+, K^+,Ca^+, Mg^{2+})

The results on Na^+ indicate a statistically significant difference between traditional tillage (0-15cm) and No-tillage (15-30cm).Similarly, a statistical significant difference between mulch tillage at 15-30cm and No-tillage at 0-15cm and 15-30cm was also indicated using a multiple comparison (LSD). It is clear that tillage systems do have an impact on the Na^+ level of soils, but it was noted that Mulch tillage system is more effective at increasing the Na^+ level (0.58 and 0.47meq/100gsoil) at depths of 0-15cm and 15-30cm, respectively. It was also noted that No-tillage is more effective at reducing the Na^+level (0.29 and 0.27meq/100gsoil) at depths of 0-15cm and 15-30cm, respectively. The results on K^+reveal no statistically significant difference between all the tillage types and No-tillage. This is so across the depths of 0-15 and 15-30cm. From these results, it is clear that tillage systems do not have any impact on the K^+levelin soils.

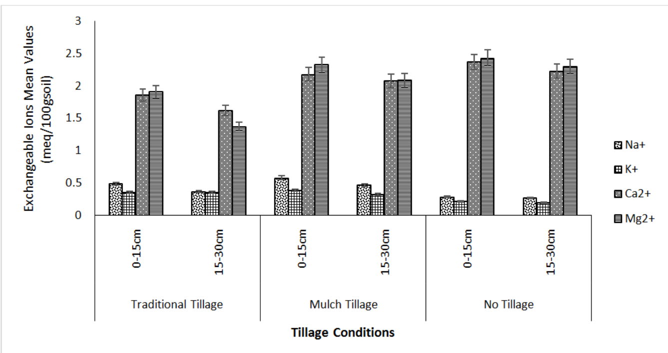

Fig. 3. Exchangeable ions at different soil tillage conditions

The results on Ca+ indicates a statistically significant difference between all tillage types this is so across the depths of 0-15 and 15-30cm. Also the statistical analysis revealsthat Ca^+ mulch tillage at 0-15cm and 15-30cm are insignificantly related. From these results, it is clear that tillage systems do have an impact on the Ca^+level in soils, but it was noted that No-tillage system is more effective at increasing the Ca^+level (2.37 and 2.23meq/100gsoil) at depths of 0-15cm and 15-30cm respectively. The results on Mg^{2+} revealed a statistically significant difference between all tillage types this is so across the depths of 0-15 and 15-30cm. Also Mg^{2+}Mulch tillage at 0-15cm and 15-30cm are statistically insignificant. From this result, it is clear that tillage systems do have an impact on the Mg^{2+} level in soils, but it was noted that No-tillage system is more effective at increasing the Mg^{2+} level (2.43 and 2.30meq/100gsoil) at depths of 0-15cm and 15-30cm respectively. It is also noted that Traditional tillage is more effective at reducing the Mg^{2+}level (1.91 and 1.37meq/100gsoil) at depths of 0-15cm and 15-30cm respectively.

Soil pH

Depictsthat the soil is slightly acidic. SoilpH show a statistically significant difference between traditional tillage (0-15cm), Mulch tillage (0-15cm) and No-tillage (0-15cm and 15-30cm) using multiple comparison (LSD). Mulch tillage at 15-30cm has a statistically significant difference with No-tillage at 0-15cm and 15-30cm, respectively. From these results, it is clear that Traditional, Mulch and No-tillage systems do have an impact on the pH level of soils, but it was noted that Mulch tillage system is more effective at maintaining and increasing the pH level (6.05) at depths of 0-15cm to a neutral level depending on the type of crop.

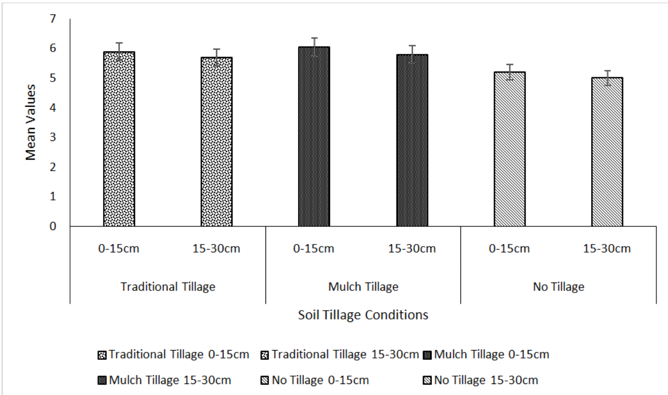

Fig 4. Soil pH at different tillage conditions

Conclusion

Inappropriate tillage systems have been identified as major constraints to the production of staple food crops especially maize. The traditional tillage system provides a more favorable soil environment for crop growth and yield than those which are planted using mulch and No-tillage systems. The difference in crop yield was as a result of the high bulk density which is as a result of soil compaction that led to reduced crop production. However, traditional tillage system is found effective in reducing the bulk density and particle density of the soil. Traditional tillage system is also found to be effective in increasing soil moisture content which serves as an important factor for adequate crop production and yield. Mulch tillage system is found effective for the increase of porosity and organic carbon percent in the soil, Na^+ and Mg^+ and also for maintaining and balancing the soil pH level while No-tillage is found more effective for increase of silt and Ca^+ in the soil. However for the land to be effectively utilized under the set three tillage system, the use of fertilizers is necessary due to the low nutrients observed in the soils. Based on the observed results, the traditional tillage should be given the highest priority for maize production in the savannah vegetation for optimum performance, proper soil management and economic benefits as it has a statistically significant difference on all the parameters studied except two which are total nitrogen and K^+. Traditional tillage (the ridge method) has been found to be an effective soil conservation practice, which can reduce soil degradation in the study area considering the soiltypes.

REFERENCES

Ahmad, M. Iqbal, B. Ahmad, G. Ahmad and N. H. Shah, Cereal Crops Research Institute (CCRI) Pirsabak, Nowshera, NWFP, Pakistan. Published in *Journal of Agriculture Biological Science* 1 (1):19-29 (2009). A Biannual Publication ofPMAS Arid Agriculture University Rawalpindi.

Aikins, S.H.M. and Afuakwa, J.J. (2010) Effect of Four Different Tillage Practices on Cowpea Performance. *World Journal of Agricultural Sciences*, 6, 644-651.

Brady, Nyle C., R.R. Weil (2002). The Nature and Property of Soils, 13th edition. New Jersey: Prentice Hall. *ISBN 0-13-016763-0*.

Mahdi Al-Kaisi; Mark Hanna; Michael Tidman (2002). "Methods for Measuring Crop Residue". Iowa State University. Retrieved 28 December 2012.

Wang, G.G., Siemens, A., Keenan, V.,Philippot, D. (2000). Survival and Growth of Black and White Spruce Seedlings in Relation to Stock Type, Site Preparation and Plantation Type in Southeastern Manitoba. 76(5):775–782.

****