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EVALUATION OF THE EFFECT OF SOIL PHYSIOCHEMICAL PROPERTIES ON MAIZE YIELDS, USING FAMER'S TILLAGE PRACTICES IN MUBI NORTH LOCAL GOVERNMENT AREA, ADAMAWA STATE - NIGERIA

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ABSTRACT

This research was conducted to assess the effect of different tillage practices on soil physiochemical properties and maize yields. The experiment consisted of four treatments namely: no-till, ridge, mulch and strip till. Soil samples were collected at different farm sites between 0 -20cm and 20 – 40cm, which was later analysed in the laboratory and the result obtained from the laboratory were subjected to a statistical tool to determine the physiochemical properties of the soil using analysis of variance (ANOVA) at $p < 0.05$. The tillage systems considered were no-till, ridge, mulch and strip till. The results showed

Introduction

The alarming rate of increase in global population which is expected to rise up to 9.7 billion (26%) by 2050 (United Nations, 2019) has created an urge to improve soil health for ensuring food security and to build a sustainable future (Amundson et al., 2015). Agriculture can assist to achieve the majority of the United Nations' sustainable development objectives, and no-tillage is the best way to do so (Mondal & Chakraborty, 2022). These issues could be

that there is a significant difference in soil parameters at $p < 0.05$ among the tillage systems. The no - tillage system resulted to the most favorable soil environment, for crop growth and best performance of crop followed by ridge tillage and mulch-tillage system in the area studied. The significant difference in yields adduced due to lower bulk density, higher water holding capacity and porosity which increased plant root proliferation and optimal utilization of soil nutrients under tilled methods. Hence tillage methods have the capability to increase production while no-tillage is better under long term production for sustainable land use.

Keywords: effects, soil, tillage, physiochemical, properties, yields.

addressed in part by management practices such as conservation tillages, which protect the soil surface from erosion, restore soil fertility through organic matter cycling, improve soil health through habitat enhancement, and reduce greenhouse gas emissions through soil carbon accumulation and improved fertilizer use efficiency (Farmaha et al., 2022). Turning the soil before planting a fresh crop is an age-old practice that contributes to farmland degradation (Derpsch et al., 2010).

Tillage is a major contributor to agricultural land degradation, which is one of the world's most critical environmental issues, posing a threat to food production and rural lives. Soil conservation for agriculture is centred on increasing agricultural production by improving soil fertility while minimizing environmental damage, notably in terms of soil and water management (Cassol et al., 2007; Kumar and Chopra, 2013 and 2016). Conservation tillage strategies with minimal soil disturbances, such as no-tillage or sub - soiling, and straw retention or mulching systems, can help increase agricultural sustainability (Chen et al., 2019). To maintain and preserve soil health, conservation agriculture management approaches such as minimum soil disturbance, maximum soil cover, and crop diversity have been recommended (Farmaha et al., 2022). Soil conservation strategies include no tillage (NT), reduced tillage (RT), and minimum tillage (MT), which can be combined, or not combined, with crop residue mulching on the soil surface, crop rotation, cover cropping, and integrated pest and weed control practices (Lal, 1993).

As a result, no-tillage agriculture is a long-term agricultural system that meets farmers' economic needs, solves consumer concerns, and has a low environmental impact (Bagwell et al., 1989).

Soil tillage is used for a variety of reasons, including preparing a seedbed for the next crop, incorporating crop leftovers and nutrients into the soil, suppressing weeds, and improving the soil's bio-physical structure (Chen et al., 2022). Tillage has also aided in the control of insects and diseases by burying crop left- overs (Givens et al., 2009). Tilling for crop production is one of the most well-known human interventions that disrupts soil aggregation, pore-size distribution, and water transport, among other things (Guo and Gifford, 2002; Kumar and Chopra, 2016).

Tillage procedures, on the other hand, have been linked to the dangers of subsurface compaction (plough pan) and soil erosion (Busari et al., 2015). Soil health has been found to be harmed by repeated tillage and residue burning for fine seedbed preparation (Somasundaram et al., 2017). Tillage procedures alter the amount of water in the soil, the temperature, aeration, and the degree of crop residue mixing within the soil matrix (Kladivko, 2001). Because of changes in infiltration, surface runoff, and evaporation caused by tillage, soil water content is another factor that is affected (Fabrizzi et al., 2005). Soil erosion, degradation of soil structure, increased nutrient depletion, and lower water retention capacity are all consequences of traditional tillage techniques (Saleem et al., 2022). Because of the physical disruption of the soil, the burying of crop residue, and the change in soil water and temperature caused by residue assimilation, larger creatures appear to be more susceptible to tillage operations than smaller organisms (Kladivko, 2001). Tillage erosion has been highlighted as a major global soil degradation process that must be taken into account when evaluating erosional effects on soil productivity, environmental quality, or landscape development (Van Oost et al., 2006). After several decades of tillage, the scope and severity of tillage erosion becomes apparent. The aim of this study is to assess tillage practices for soil conservation among farmers in Mubi North Local Government Area. In order to achieve the stated

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aim, the study sought to examine the following objectives: to identify the conservation tillage practices mostly used by farmers in the study area, to examine those factors that informs farmer's choice of a particular tillage practice and to determine farmer's output of maize per hectare using different tillage practices

Materials and Methods

The study area

The study area is Mubi north and its environs. Mubi is a town in northan senatorial district of Adamawa state, Nigeria located between latitude 9^0 30' and 11^0 00' north of the equator and longitude 13^0 00' and 13^0 45' east of the Greenwich meridian. The study area is however, bounded in the north by Michika Local Government, in the East by the Republic of Cameroon, while it shares boundary with Hong Local Government and Borno State to the west and Maiha Local Government as well to the South. It has a land area covering 4728.77km^2 (Adebayo, 2004), this is shown in figure 1:

The study area falls within the North East basement complex of Nigeria. According to Adebayo and Dayya (2004), the rocks are pre-pan African Organic rocks (Genesis Gigmatite rocks) or pan Africa deformation and NE-SW making the pan Africa thermodynamic events. The hard crystalline rock forms a series of orogenic cycle within the belt of Central Africa. (Bassey, 2004 in Adebayo, 2004)

The climate type is tropical continental which is dominated by wet and dry season, coded AW in the Koppen's climate classification. The temperature in the area ranges from warm to hot throughout the year due to high incoming solar radiation, even though there is usually a cool period in the month of November and February.

The study area is made up of mostly high lands with series of mountain ranges lying along its eastern border with Cameroun, with some few outcrops of hills around Vimtim and Mayo-Bani. The area is characterized by hills/mountains ranges, up-land plains and lowland valley troughs (Tukur, 1999 in Adebayo, 2004). The mountainous area rise to the heights of 455 meters to 1065 meters above sea level. The predominant drainage system in the area is Rivers

Yadzeram (Adebayo and Dayya, 2004). It takes its source from Gella hills in the southernmost part of Mubi and flows through the region in a south-north direction which eventually empties into Lake Chad. The river has many tributaries that are perennial in nature which consists Mayo Bani, Digil and Muvur River all within Mubi.

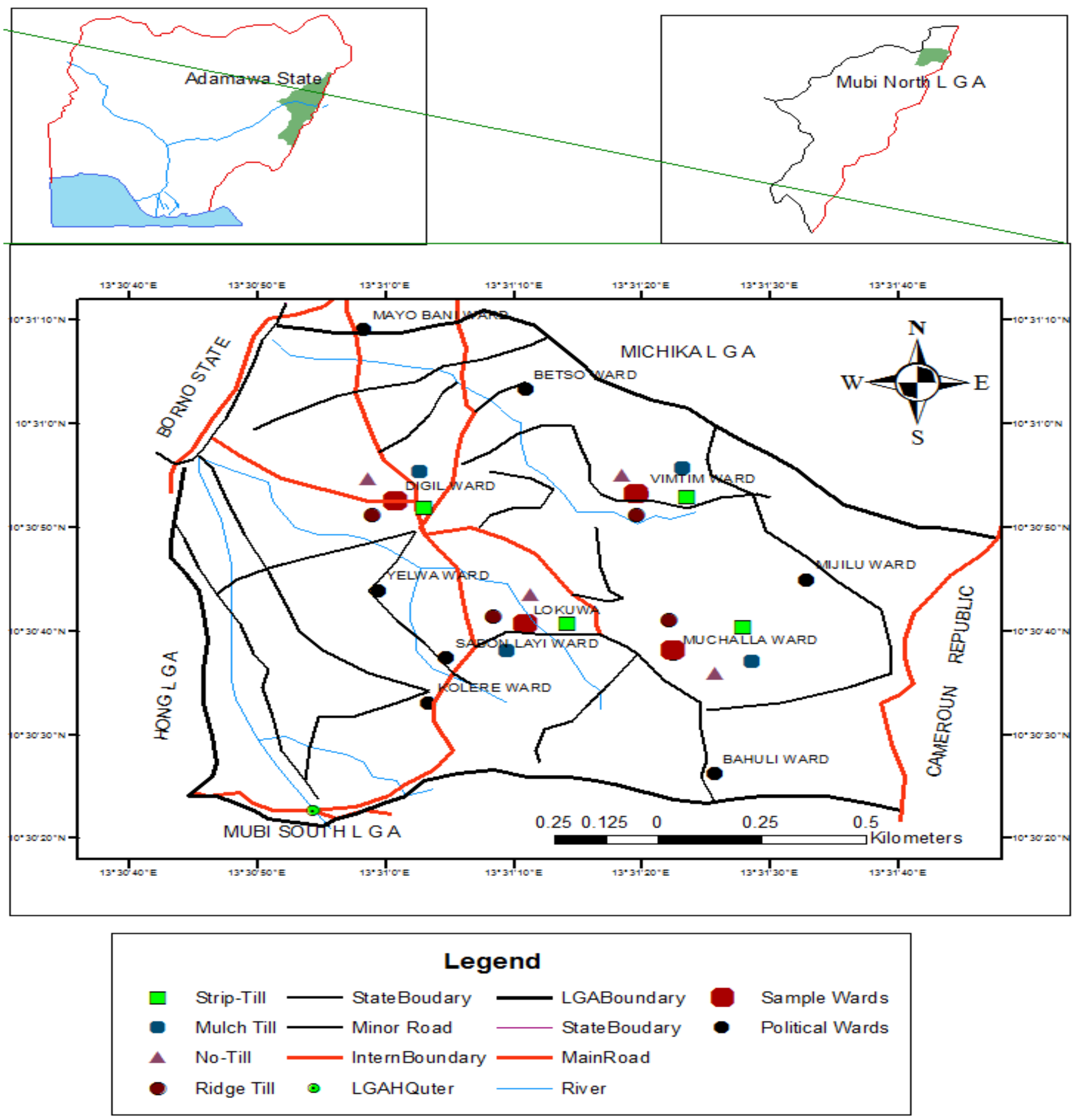

Figure 1: The Study Area

Population for the study

The study used the total number of registered farmers 10,093 in the study area as obtained from Adamawa Agricultural Development Programme, Mubi (AADP, 2013). And this formed the population for the study as presented in Table 1:

Table 1. Population Distribution

Wards	Population	Percentage
Digil	826	21.42
Lokuwa	886	22.97
Muchalla	1286	33.34
Vimtim	859	22.27
Total	3,857	100

Source: AADP, 2024

Sample size and sampling techniques

The sample for this research was determined using Yamane (1973) formula at 95% confidence limit. The study area comprises eleven (11) wards namely; Muchalla, Mijilu, Bahuli, Vimtim, Sabon-Layi, Yelwa, Mayo-Bani, Kolere, Lokuwa, Betso, and Digil. A purposive sampling technique was used to select four (4) wards representing 40% of the total wards. The wards selected were Digil, Lokuwa, Muchalla and Vimtim, and the selection was based on the fact that, they were the wards where such tillage practices are mostly practiced.

Soil Analysis

For laboratory analysis, the soil physical and chemical properties tested include; particle size, bulk density, porosity, soil pH, Organic Carbon (OC), Exchangeable Bases (EC), Base saturation (BS), Effective Cation Exchange Capacity (ECEC), Electrical Conductivity (EC), Exchangeable Acidity (EA), Total Nitrogen (TN), Available phosphorus (AVP).

Data Analysis

Surface samples (0 - 20 cm) and sub-surface samples (20 - 40 cm) were taken at the lower slope selected for the research. In addition to the above, a representative profile pit was dug and samples were taken from it. These were later air-dried, crushed and sieved before taken to the laboratory for physical and chemical analyses of the soils. The data for this study was analysed through software package (SPSS Statistical Package for Social Sciences). The demographic background information of the respondents was presented using descriptive statistics in form of frequency and percentage. Also, soil sample were presented using analysis of variance (ANOVA.

Determination of soil physical properties

Bulk density: bulk density of the soil was determined using undisturbed core soil sampling as described by Blake and Hartage (1986). Bulk density in the 0-20 cm and 20-40 cm layers were determined using core method. The collected soil core was trimmed to the exact volume of the cylinder and oven dried at 105^{o}C for 24 hours. And bulk density was determined from the ratio of mass dry soil per unit volume of soil core

Particle size: the particle size analysis of the soil was determined using hydrometer method (IITA, 1979). 10 g of 2 mm air-dry sample was placed into a 400 mL beaker with approx. 20 mL distilled water and 10 mL of 35% H_2O_2 and covered with a watch glass. After reaction has subsided, another 5 mL of 35% H_2O_2 added and sample left overnight for digestion. Sample was placed on a hot plate at a low temperature for further digestion, with additional H_2O_2, until frothing ceases, with Soil adhering to the sides of the beaker or watch glass was washed down with distilled water, bringing the volume up to approx. 400 mL.

Soil porosity: the soil porosity was determined as described by (Brady and Well, 2002). The porosity of soil between 0-20 cm and 20-40cm layers were calculated from the values of the dry bulk density ad assumed particle desity of 2.65 g/cm^3.

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Determination of soil chemical properties

Soil pH: Soil was measured in a 1:2, soil to water ratio using a glass electrode (H19017 microprocessor) pH metre (Jaiswal, 2003). Twenty (20 g) of the soil samples was weighed into a 250 cm^3 beaker and 100 cm^3 of distilled water was added. The mixture was stirred at regular interval for 1 hour to ensure effective dispersal and dissolution of all soluble compounds. The pH metre was calibrated with a buffer solution (the neutral range). The pH was then recorded using a pH metre.

Soil electrical conductivity: The soil EC was measured in a 1:2, soil to water ratio using a glass electrode (H19017 microprocessor) EC meter (Jaiswal, 2003). Twenty (20 g) of soil sample was weighed into 250 cm^3 beaker and 100 cm^3 of distilled water was added. The mixture was stirred at regular interval for 1 hour to ensure effective dispersal and dissolution of all soluble compounds. The conductivity meter (Kent Eil 5007) was used to record the conductivity of each sample. After each test, the electrode of the conductivity meter was thoroughly rinsed with distilled water

Total nitrogen (N): Total nitrogen was determined by the macro kjedahl digestion, distillation and titration procedure (Jaiswal, 2003), however, 20g of sieved soil was transferred into 1 litre round bottom flask. Little distilled water added with the help of jet in such a way that the particles of soil do not remain stuck to the sides of the flask. 2 to 3 glass beads were added to present bumping and 1 ml of liquid paraffin to prevent frothing. 100 ml of potassium permanganate and 100 ml of sodium hydroxide solution added to the flask (both solutions prepared fresh) and the distillate in a beaker containing 20 ml of boric acid working solution collected. Approximately 150 ml of distillate collected, titrate the distillate with standard H2SO4 0.02N till the colour changes from green to red and record the burette reading.

Available phosphorus (AVP): The available phosphorus of the soil sample was determined using Bray 1 method (Bray and Kurtz, 1945). 2.5 gm of soil sample weighed in 150 ml plastic conical flask, added to pinch (0.3 gm) of phosphate free activated charcoal AR grade. 50 ml of Olsen reagent was added and shaked for 20 minutes exactly on platform type shaker at 180 rpm. The contents filtered immediately through filter paper. 5 ml of aliquot transferred

into 25 ml volumetric flask. 5 ml of filtrate Pipette out into 25 ml volumetric flask and 4 ml of the freshly prepared ascorbic acid and ammonium molybdate solution added, Shaked well and kept for 30 minutes. However, standard curve was prepared using 0, 1, 2, 3, 4 & 5 ml of 5 ppm standard P solution into 25 ml volumetric flask and develop the colour using the same procedure as above. The corresponding P concentration is 0, 0.2, 0.4, 0.6, 0.8 & 1 ppm. The absorbance and colour intensity at 882 nm after half an hour was measured.
Organic Carbon (OC): Organic Carbon was determined using Bray 1 method. Soil sample was sieved with 1 mm sieve and 1 gm of sieved soil sample in 100 ml flask taken. 10 ml potassium dichromate and 20 ml sulphuric acid was added, well shocked and allowed to cool on asbestos sheet. The volume was made to 100 ml with distilled water and kept overnight. Optical density was measured at 660 nm wavelength on spectrophotometer.

Organic Carbon % = Optical density x Factor F
Effective Cation Exchange Capacity (ECEC): The ECEC was determined by summation method (IITA, 1954). Effective CEC (ECEC) was calculated for acidic soils by summing the CEC by bases and the exchange acidity.
ECEC = CEC by bases + exchange acidity
= Ca + Mg + K + Na + Al + H
Percentage Base Saturation (PBS): The PBS was determined by calculation.
Base status
= (CEC by bases / clay%) x 100

Exchangeable acidity in soil: The soil was extracted with unbuffered 1.0M KCl, and the sum of Al and H were titrated with 0.M NaOH in the presence of phenolphthalein indicator to a permanent pink colour (Jaisawal, 2003).
Exchangeable Base (EB): Exchangeable base was extracted with one normal (1N) ammonium acetate. Potassium and sodium were determined using flame photometer, while calcium and magnesium were equally determined by titration with 0.01N EDTA (ethylene di-aminotetra-acetic acid) as described by Jaiswal (2003).

RESULTS AND DISCUSSION

Respondents Tillage Practices

The distribution of respondents by tillage across the wards in Table 2, reveals that majority of the respondents making up to 64% practice ridge till, 21% no-till and those practicing mulch and strip tillage are 10% and 5% respectively. These results indicated that ridge-till is the most common practice, followed by no-tillage. However, the result further indicates that farmers in the study area are not either aware of the benefit of other practices or lack the financial strength to switch to another tillage practice, and majority of farmers that acquire their farmlands through rent age or hire in the study area often engage in tillage practices that yield more farm output but less soil conservation.

This finding collaborates to IITA (1990); Reeves (2004); Ibeawuchi (2007) and Meisiner *et al.* (2009) that land tillage leads to soil degradation. However, Havlin *et al.* (2008) expressed variability effect of particular tillage practices and soil conservation. He reported further, that no till or zero tillage is most efficient techniques in terms of soil conservation, followed by strip, mulch and ridge till. More so, Knight *et al.* (2012) expressed that excessive tillage of agricultural soils may result in short term increases in fertility, but will degrade soils in the medium term. Structural degradation, loss of organic matter, erosion and falling biodiversity are all to be expected when inappropriate tillage is constantly practiced, farmers in the medium term of continuous tillage will experience soil erosion.

According to Ajayi and Solomon (2010), adequate information with adequate follow up will only be useful to farmers alongside continuous use of improved technologies like soil conservation techniques. They expressed that when farmers are well aware of best soil conservation practices that are capable of yielding expected farm output, majority of farmers tend to adopt swiftly.

Table 2: Respondent's Tillage Practices

Gender	Digil		Lokuwa		Muchalla		Vimtim		Overall	
	Fx	%	Fx	%	Fx	%	Fx	%	Fx	%
No Till	18	23%	18	22%	26	21%	14	17%	76	21%
Ridge	47	60%	52	63%	74	61%	58	72%	231	64%
Mulch	9	12%	8	10%	13	11%	7	9%	37	10%
Strip	4	5%	5	6%	8	7%	2	2%	19	5%
Total	78	100%	83	100%	121	100%	81	100%	363	100%

Fx: frequency, %: percentage,
Source: Field work, 2024

Impact of Tillage Practices on Soil Physical properties

The main physical properties analysed for this study were; particle size distribution, bulk density, and porosity. Most of these properties were generally used to describe the soil physical state and quality. By knowing the physical properties for each tillage treatment, critical evaluations can be performed to find the most sustainable tillage practice for the specific soil.

The results of soil physical properties obtained from the laboratory analysis presented in Table 3 reveals that the mean proportion of sand across the four wards is much more in no – till sites than the respective practices. From the observed results, Digil ward for example, has mean proportion of 86.41 in no-till sites, than strip till site having 78.5, while ridge and mulch till show mean proportion of 78.7 and 80 respectively, which is slightly less than no - till. It was observed that sand is more in no-till sites than the other three tillage. The reason might not be far from the fact that ridge; mulch and strip till make soil lighter and more erodible than no-till where the soil is left completely undisturbed. However, these differences were not statically significant at (p-values >0.05) across the four tillage types. Tallman (2013) expressed that tillage has small but persistent degradation effect on land which might take years to be noticed. Thus, the less sand found in other practices indicated by this study suggest the negative impact of tillage systems on soil over the no-till.

The proportion of silt across the four awards presented in Table 3 reveals that no-till has a mean silt proportion of between 9.1 – 9.7, 11.80 for ridge and strip till, with mulch till having a mean proportion of 12.2. These results indicate that mulch till has more presence of silt than the respective no-till, ridge and strip till sites. This further reveals that there is a significant difference at (p-value <0.05). This result shows that most of the areas under cultivation resulting from inappropriate tillage systems have lesser silt due to soil exposure and continuous erosion. According to Singh *et al.* (1994) soils with relatively high contents of silt and fine sand have a tendency towards structural instability and compaction, particularly if the organic carbon content is low.

Similarly, Table 3 presents the mean percentage of clay across the four sampled wards for the four tillage practices in the study area. No – till has a mean clay of 4.2, ridge till has 10.7 - 10.9 and 8.8, 10.7 for mulch and strip respectively. The result indicates that there is a significant difference in the mean proportion of clay recorded in no – till than the other three at (p-values <0.05), this implies that clay properties are less in no – till than other practices. It was also observed at both sampled depth that tillage intensiveness or amount of soil disturbance increase clay content of soil in the study area.

The average bulk densities of the different tillage practices across the four wards show the following results: no-tillage 1.73 g/cm^3, ridge till 1.57 g/cm^3, mulch till 1.62 g/cm^3, and strip till1.59 g/cm^3 for most of the wards. As observed from the result, one can see that the bulk densities of all the treatments are generally low, although no-tillage had the highest bulk density of the treatments. Similarly, when looked at the different tillage treatments; ridge, mulch and strip tillage had a less bulk density. No-tillage had higher bulk densities because it constitutes little or no soil disturbance. Intensive tillage treatments destroy aggregates and soil structure and as a result create many macro pore and decrease bulk density. The result affirm that there were insignificant differences for all the recorded bulk density for the respective tillage in the study area at (P-value >0.05).

Similarly, the mean percentage of porosity recorded for the four wards were 67.55%, 59.74%, 61.12% and 59.22% for no-till, ridge, mulch and strip till respectively. Porosity differs among tillage systems, no-till decrease soil porosity and poor aeration, but increase capillary porosity; as a result it enhances the water capacity of soil along with bad aeration of soil. This result implies that there were no significant differences in soil porosity for the four tillage systems at 0.05 levels.

Table 3: The Impact of Tillage Practices on Soil Physical Properties

Physical Properties	No-Till			Ridge Till			Mulch Till			Strip Till			P-value
	Mean	Std. Dev	Cvar	Mean	Std. Dev	Cvar	Mean	Std. Dev	Cvar	Mean	Std. Dev	Cvar	
Digil Ward													
Sand	86.41	2.83	0.03	78.7	2.82	0.03	80	0.71	0.01	78.5	28.2	0.03	0.13
Silt	9.1	2.12	0.23	11.8	0	0	12.2	0.72	0.05	11.8	0	0	0
Clay	4.31	0.72	0.18	10.7	1.34	0.13	8.7	0	0	10.9	28.2	0.24	0.04
Bulk D.	1.73	0.01	0.03	1.57	0.04	0.04	1.62	0	0	1.59	0.05	0.04	0.12
Porosity	67.55	2.04	0.02	59.76	2.73	0.03	61.2	2.14	0.03	59.21	2.03	0.05	0.04
Lokuwa Ward													
Sand	85.5	2.84	0.04	78.5	2.84	0.03	79.9	0.69	0.03	78.4	28.2	0.05	0.16
Silt	9.7	2.13	0.25	11.8	0	0	12.24	0.70	0.07	11.7	0	0	0.02
Clay	4.29	0.71	0.17	10.7	1.36	0.15	8.9	0	0	10.6	28.3	0.23	0.04
Bulk D.	1.73	0.01	0.02	1.57	0.04	0.04	1.62	0	0	1.58	0.07	0.05	0.15
Porosity	67.55	2.06	0.02	59.75	2.72	0.05	61.3	2.11	0.04	59.22	2.02	0.03	0.03
Muchalla Ward													
Sand	86.39	2.84	0.04	78.6	2.84	0.03	80	0.71	0.03	78.4	28.4	0.05	0.15
Silt	9.5	2.12	0.25	11.9	0	0	12.25	0.68	0.06	11.7	0	0	0.03
Clay	4.29	0.7	0.18	10.9	1.31	0.15	8.9	0	0	10.8	28.2	0.23	0.01
Bulk D.	1.72	0.02	0.02	1.58	0.05	0.03	1.63	0	0	1.57	0.06	0.05	0.14
Porosity	67.54	2.06	0.02	59.76	2.73	0.04	61.1	2.12	0.03	59.22	2.04	0.03	0.04
Vimtim Ward													
Sand	86.38	2.85	0.04	78.4	2.82	0.03	79.8	0.71	0.02	78.5	28.3	0.03	0.11
Silt	9.4	2.12	0.25	11.8	0	0	12.21	0.70	0.05	11.9	0	0	0.04
Clay	4.28	0.72	0.17	10.8	1.41	0.15	8.9	0	0	10.6	28.3	0.25	0.03
Bulk D.	1.73	0.01	0.02	1.56	0.04	0.05	1.61	0	0	1.57	0.05	0.03	0.12
Porosity	67.55	2.07	0.04	59.74	2.72	0.04	61.3	2.12	0.03	59.24	2.03	0.05	0.03
Overall													
Sand	86.4	2.84	0.04	78.6	2.83	0.03	79.93	0.71	0.02	78.45	28.28	0.04	0.14
Silt	9.4	2.12	0.25	11.83	0	0	12.24	0.69	0.06	11.78	0	0	0.02
Clay	4.29	0.71	0.18	10.78	1.40	0.15	8.85	0	0	10.73	28.25	0.238	0.03
Bulk D.	1.73	0.01	0.02	1.57	0.04	0.04	1.62	0	0	1.578	0.058	0.043	0.13
Porosity	67.5	2.06	0.03	59.75	2.73	0.04	61.2	2.12	0.03	59.22	2.03	0.04	0.04

Std. Dev: standard deviation, Cvar: Coefficient of Variation.

Source: Field work, 2024

Impact of Tillage on Soil Chemical Properties

Table 4; Presents the laboratory analysis of soil chemical properties in the study area. The result indicates that the soil pH across the four tillage practices is slightly acidic as observed from the mean values. The study shows that under no-tillage, soil pH tended to decrease, but this decrease was also not significant at 0.05 levels. Therefore, lower pH as a result of no-tillage can be explained by increased acidification due to higher mineralization rates, and acidification occurs due to mineralization of organic matter, and the effect of nitrification of added fertilizer and root exudation. The findings conformed to the study carried out in Liberia by Lal and Dinkins (1979), which demonstrated that no-tillage is effective for the production of grain crops but the yield of cassava was higher in plough than no-till plots.

Electrical conductivity (EC): The result in table 4 also revealed the mean proportion of electrical conductivity in the study area.

However, the result indicates that the soil is generally non-saline. This was also confirmed by the study conducted, normally one would expect a higher EC reading in no-tillage practice because fertilizer is only applied to the topsoil at planting, leading to an accumulation in the 0-15 cm soil profile. Even though, other practices also received fertilizer in the same way, but because soil is tilled once every year, the fertilizer is incorporated evenly over 0-20 cm soil depth in which 0-15 cm depth is expected to show a lower EC reading. This was further confirmed at 0.05 levels that there was no significant difference between no-till and the three tillage treatments.

The results of total carbon content for the different tillage treatments of the two sampling depths and sites across the four wards show that, the total carbon content were very low for all the tillage treatments. The results from this study, showed that there was decrease in total carbon content of no-tillage and that of strip tillage treatments, which incorporates residues below ground, and reduces the total carbon content of the soil even-though, not significant. It was expected that no-tillage treatment would have increased the carbon content of the soil to much higher percentages, a phenomenon that is well documented in many literatures, but this was not observed in our study.

However, there was no significant difference at 0.05 levels in the organic carbon content of the soil across the four tillage practice in the study area.
The finding also, indicates that the percentage of total nitrogen across the four tillage practices is nearly the same. It was established that there was no significant differences in the practices at different depths at 0.05 levels. In a similar manner, the result of analysis reveals the mean values of available phosphorus obtained in the study area for the four wards are generally low. The result indicates that the phosphorus levels are nearly the same except for the no-till and strip that was slightly higher and this result is not in contrast with what was earlier expected. It was observed from the result that the phosphorus level of farmlands in the study area is insignificant. The calcium content of soil in the study area as observed from the mean values was generally very low. However, it can be deduced from the result that the calcium content of soils in the area is not fairly uniform, because different practices receive different treatment hence differences in calcium content of the soil. It was further established at 0.05 levels, that there were significant differences in the soil calcium content across the four practices in the study area.
In addition, result on magnesium content of soil across the four practices range from low to medium. It was observed that ridge and strip till have higher magnesium content than those of no-till and mulch farmlands across the four wards. This result indicates that there were significant differences in the magnesium content of the soil at various depths and sites. Similarly, a result on sodium content across the four tillage practices is generally low. This was observed from the computed mean values that, the sodium content of all the sampled farmlands are nearly the same. It was established that the sodium content of soil at various depths and sites were not significantly different. Also, the finding reveals the available potassium of soils in the study area. The result as indicated at different depths and sites show that the available potassium in no-till and strip till are slightly higher than those of ridge and mulch till farmlands. This was also confirmed at 0.05 levels that there were no significant differences in the potassium level of all the practices.

More so, the result on Total Exchangeable Bases (TEB) and Total Exchangeable Acidity (TEA) were not statistically significant across the four wards, while the Effective Cation Exchange Capacity (ECEC) and Base Saturation (BS) were statistically significant. As can be seen from the table, the mean values of exchangeable bases are slightly higher in no-till and mulch than ridge and strip till farmlands, while Exchange Acidity for all the practices is nearly the same. However, Effective Cation Exchange Capacity is much higher in mulch and no-till than the other two farmlands at different depths. Base Saturation, on the other hand is much more in mulch and no-till farmlands than the other two practices.

Table 4: Tillage Effects on Soil Chemical Properties

Chemical Properties	No-Till			Ridge Till			Mulch Till			Strip Till			P-value
	Mean	Std. Dev	Cvr	Mean	Std. Dev	Cvr	Mean	Std. Dev	Cvr	Mean	Std. Dev	Cvr	
pH	6.35	0.2	0.03	5.4	0.14	0.03	6.5	0.21	0.03	5.42	0.13	0.02	0.05
EC (dsm)	0.2	0.2	0.11	0.14	0.04	0.3	0.13	0.03	0.22	0.15	0.04	0.28	0.28
%OC	0.72	0.4	0.06	0.78	0.04	0.05	0.78	0.18	0.23	0.73	0.03	0.04	0.3
%N	0.09	0.1	0.16	0.08	0.01	0.09	0.1	0.01	0.07	0.08	0.01	0.09	0.35
AVP (PPM)	3.99	0.4	0.1	3.58	0.74	0.21	3.02	0.88	0.24	3.63	0.81	0.22	0.58
Ca (Cmol/k)	4.7	0.4	0.03	2.15	0.07	0.02	5.3	0.71	0.13	3.15	0.07	0.02	0.02*
Mg (Coml/k)	0.9	0.4	0.16	1.1	0.99	0.9	0.85	0.35	0.42	1.05	0.92	0.88	0.82
Na (Cmol/k)	0.14	002	0.16	0.12	0.01	0.06	0.13	0.01	0.06	0.1	0	0	0.4
K (Cmol/k)	0.82	0.4	0.48	0.69	0.02	0.03	0.48	0	0	0.71	0.02	0.03	0.71
TEB (Cmol/k)	6.6	0.57	0.09	5.02	1.02	0.2	6.81	0.44	0.06	5.01	1.01	0.2	0.23
TEA (Cmol/k)	1.25	0.7	0.06	1.7	0	0	2.1	0.28	0.13	1.8	0	0	0.07
ECEC	7.98	0.69	0.09	6.81	1	0.15	8.67	0.06	0.01	6.81	1.01	0.15	0.32
%BS	83.7	0.36	0	63.27	4	0.05	88.28	1.35	0.05	73.25	3.97	0.05	0.04*

Cvar: Coefficient of Variation, Std.Dev: Standard Deviation
Source: Field work, 2024

Conclusion

Conservation tillage and cover cropping protect the soil surface from erosion, restore soil fertility through organic matter cycling, improve soil health

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through habitat enhancement, and reduce greenhouse gas emissions through soil carbon accumulation and improved fertilizer use efficiency. Conservation farming techniques using cover crops and no-till or reduced tillage have been found to improve soil health. The goal today is to focus on long-term land development methods that allow existing populations to meet their demands without putting resources at risk, while also safeguarding resources for future generations.

Recommendations

The following recommendations were made based on the findings:

i. No-tillage is the best practice due to its ability towards conserving soil and less environmental impact.
ii. Implementation of no-tillage may vary according to local conditions; farmers should collaborate with researchers and non-governmental organizations so as to have better understanding of the system.
iii. Government should sensitize farmers on the need for appropriate tillage through their extension workers.
iv. Farmers should be encouraged to have a well thought plan that encompasses soil testing, crop rotation, and soil compaction and how it will affect other farm enterprises.

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